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FACULTATIVE AND OBLIGATE HETEROTHALLISM IN ASCOMYCETES

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(WITH 2 FIGURES)

You have heard the Secretary's report on the 1935 mycological foray. I am sure the Society is very grateful to Professors Fitzpatrick, Whetzel, and their associates, for their efficient work in organizing last summer's meeting. The 1934 foray was held at a camp site in the midst of good collecting grounds. This year at Cornell University we had the use of one of the best equipped botanical laboratories in the country. As between the two situations I should prefer a location where we could display our collections in such a way that every one could see what the others had gathered. We all profited from this advantage at Cornell. It does not need to be a large laboratory, and the equipment need not be expensive. I hope that in the near future we may be able to arrange a summer meeting in the middle west. Personally, I should like to have one in Wisconsin so that I could take you over some of my old collecting grounds.

Very few of the members of our Society realized when they selected their presiding officer for the past year, that they were choosing a mycologist of the old school. If collecting and publishing a list of 550 species of fleshy fungi make one an old time mycologist, then I am one.

[1] Address of the retiring President of the Mycological Society of America, St. Louis, December 31, 1935.

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Most persons are more or less interested in mushrooms and toadstools. An early interest in this work naturally had its effect on my high school students so that the teaching of botany and physics became much easier. The boys from the rural districts near Algoma, Wisconsin, were especially enthusiastic, bringing in many specimens to be named. We had our favorite sphagnum bogs and tamarack swamps where we could always find *Boletus spectabilis*, *B. elbensis*, *B. Clintonianus*, *Boletinus palustre* and other interesting boletes in season. Unless you have been in that State you have probably never collected *Boletus sphaerosporus*. It has a rather repulsive appearance when mature, due to the purplish slime which covers the tough leathery veil and the upper part of the stipe. The flesh is solid so that when fried or broiled it makes a good substitute for beef steak. We also tested other species with bad reputations. One of my worries on these high school forays was the habit the boys had of toasting and eating any mushroom they might find. That there were no cases of poisoning in that community must have been due to the scarcity of the deadly poisonous species rather than to our expert knowledge of the species.

One misty morning in September when I was still much of a novice, we had collected two curious pinkish bodies about the size of a hen's egg, partly buried at the base of a stump. They were left in the damp paper sack on the laboratory table for an hour or so while I attended to other school duties. Upon return later instead of our two prized egg-like specimens we found sticking out through the paper two foul-smelling objects, the like of which we had never seen or heard of before. We thought that some one had switched specimens as a practical joke on the teacher. It was not until about two weeks later that we discovered that the joke was really on myself because of my ignorance of the ways of some of these fleshy fungi.

Strange as it may seem, if it had not been for Dr. Seaver of The New York Botanical Garden, I would very likely have continued taxonomic mycological work after coming to New York. He suggested as a problem for a thesis a taxonomic study of the Ascobolaceae. It was soon evident that, while there was much to be learned about species as they developed on their natural

substrata in damp chambers, it was very desirable to grow them also in pure cultures where their ascocarpic primordia could be studied. Sex is always such an interesting study that when one starts looking at ascogonia, trichogynes, spermatia and other reproductive structures of this fascinating group he is apt to forget all about the monographing of his genus.

I recall the great excitement with which, as an isolated country-town high school principal, I opened the packet which contained the first book on mushrooms which I had ever seen. The odor that came out when the book was opened, perhaps the odor of printer's ink retained in the newly printed book, has remained in my memory. I was impressed by the fine appearance of the book and noted how the shining white paper took so well the beautiful photographs of various types of mushrooms. If you know this book you can imagine how the pictures of *Dictyophora duplicata* and *Phallus impudicus* cleared up that mystery of the eggs in the paper sack. The author points out that these phalloids grow so fast as they hatch out that it is very difficult to get good photographs.

As I read the book through the night, I was further impressed with the clear and simple yet highly scientific language that was used in discussing the various topics. The selection of species for consideration was also very fortunate as we had no trouble in recognizing from the descriptions any number of forms that we had collected and studied without the help of any published works on mushrooms. Little did I think at that time of ever meeting the author of that book, and much less that I would, within a few years, be sitting in a hotel lobby in Philadelphia in violent argument with him on the merits of ascogonia, trichogynes and spermatia as evidence of a relationship between the ascomycetes and the red algae. The discussion was proceeding so violently that I felt something had to be done, and took the first opportunity to calm my opponent. I said "Why, Professor Atkinson, neither one of us knows anything about where the ascomycetes came from. I simply brought together the best evidence I could find in support of one view. I believe you did the same for your side. You even left out one of the best pieces of evidence in favor of your view." It was to his credit that,

after remaining silent a moment, he responded, "I guess you are right, Dodge, what we really need is more information regarding sex and reproduction in these fungi."

It is with the same spirit that I presume to speak today on heterothallism in the ascomycetes. Our disagreements as to the terminology are probably due to inertia as much as to our lack of knowledge concerning the processes involved in reproduction. Until much more information is obtained we must go on using terms more or less inconsistently and loosely. It was hoped to arrange a symposium or round-table discussion for this hour on the program. Each one of us could have been given the opportunity to formulate definitions of such terms as sex, maleness, femaleness, heterothallism, homothallism, hermaphroditism, incompatibility, sterility, hybrid, diploid and spermatization. Evidently we are not yet ready for such a program.

Discussing ascomycetes, can we use the terms heterothallism and homothallism in the sense in which they were first used by their author? Blakeslee found a very definite bipolar sex-reaction existing not only between races of certain species, but also between species from different genera of the Mucoraceae. It was convenient at that time to call one race of *Phycomyces* + because it produced more sporangia than did the other tester which he referred to as −. Whether this sex linked vegetative distinction holds throughout the various genera is not important. The important thing for purposes of evolution would be that +/− races have a genetic differentiation. It is also important not to confuse +/− genetic differences in heterothallic species with phenotypic cell differentiation in case of hermaphroditic species. This point is being discussed this afternoon on another program.[2] We might well agree with Kniep who, in reviewing the work of Blakeslee and Burgeff on heterothallic races of the Mucoraceae, concludes that, while there are a number of contradictions and apparent inconsistencies that must be explained away, on the whole one must believe that in the "dioecious" species sexual reaction has a chromosomal basis.

[2] Reproduction and inheritance in ascomycetes. Science II. **83**: 169–175. 1936.

TYPES OF ASCOMYCETES

Regarding the potency of species to reproduce we may roughly classify them in four or five groups.

Group 1. Certain ascomycetes like *Pyronema*, *Pleospora*, *Ascodesmis*, and probably all ascocarpic species of *Penicillium*, to cite a few well known examples, have all of their inheritance carried in a single uninucleate totipotent ascospore. Whether or not one finds differentiated organs in the primordia we may call such species homothallic comparable to *Sporodinia* and *Zygorhynchus* of the Mucoraceae. In homothallic ascomycetes we must expect certain races to be more fertile than others under our cultural conditions. Some students seek to explain sectoring, saltations or mutations in plate cultures of *Fusarium*, *Helminthosporium*, *Aspergillus* and others on the basis of heterocaryosis. Naturally if somatic mutations occur in one's cultures of a haploid mycelium, one could refer to the growth as a whole as heterocaryotic. We want to know first whether the individual cells are uninucleate or multinucleate. The ascospore of *Pyronema* is uninucleate but the cells of the mycelium are multinucleate, not heterocaryotic. Simply because one sees hyphal anastomoses is no justification for assuming that a heterocaryotic condition arises due to hyphal fusions between genotypically different races. We must have proof that there is a nuclear migration or that regeneration branches containing a mixture of nuclei actually grow out from the cell unions.

Great advances in our knowledge of the fungi have resulted from the practice of culturing from single spores. To date a large majority of ascocarpic species have proved to be homothallic.

Group 2. Holding to Blakeslee's original idea we should imply by heterothallism that in ascomycetes all races of a species fall into two main groups as to their sex-reactions. We obtain ascocarps only when two races of opposite sex are mated. *Ascobolus magnificus*, *Neurospora sitophila*, *Sclerotinia Gladioli*, *Bombardia lunata*, and *Humaria granulata* are good examples. Their asci are 8-spored, each spore contains a single nucleus at its origin, and for any pair of simple mendelian factors there will be found on analysis of all eight races from an individual ascus a 1 : 1 segregation ratio.

The list of strictly heterothallic species is slowly growing. Certain species like *Penicillium luteum* and *Fusarium moniliforme*, reported to be heterothallic would very likely prove to be homothallic on further examination.

Group 3. The most interesting of all ascomycetes to me are those species like *Neurospora tetrasperma*. Here the asci are normally 4-spored, each spore carrying at its origin two nuclei of opposite sex. *Neurospora Toroi*, *Pleurage anserina*, *P. taenioides* and *Gelasinospora tetrasperma* have a similar organization. The cytology of *Neurospora tetrasperma* has been worked out to show the unique mechanism by which each spore is provided with the two nuclei of opposite sex. Disarrangement or faulty orientation of the nuclear spindles sometimes results in cutting out one or more uninucleate ascospores in an ascus. Such spores are invariably unisexual in their reactions.

Group 4. We have species like *Glomerella cingulata*, and *G. Lycopersici* where occasionally races, according to Edgerton and Hüttig, are totipotent and thus produce fertile ascocarps, while others are either self-sterile, or produce only an occasional fertile fruit body. Rarely one finds, as first shown by Edgerton over twenty years ago, a pair of races, one "hermaphroditic" and the other unisexual, or at least less fruitful, which will, when grown from opposite sides of a plate culture form a row of ascocarps along the line where the mycelia meet. Edgerton referred to such pairs as +/− races, although both may mature some ascocarps with spores. Hüttig unaware of Edgerton's work on the subject calls the fertile races hermaphroditic and the sterile races male. According to him one may have male "sclerotia" (incipient perithecia). Edgerton made a good start in trying to analyze the eight spores from a single ascus from his matings, but it yet remains to carry such a study to a successful conclusion.

Group 5. A large number of imperfect fungi must have ascocarpic stages in nature. Whether a species can lose permanently its inheritance to produce ascocarps is a question that can never be settled. Someone once remarked to me that *Monilia sitophila* had evolved such an efficient conidial apparatus for asexual reproduction that it no longer needed ascocarps, so that they have dropped out of the life cycle. One author believes that

ascocarps of this species are not found in nature because of certain sterility factors in wild types prevent fertilization in races heterocaryotic following hyphal fusions. A study, not only of the literature but of wild types themselves discloses the fact that ascocarpic stages of all six species of *Neurospora* are very commonly produced in nature. The trouble is that persons who have found the perithecia did not recognize the connection between the monilioid and the ascocarpic stage. They did not appreciate the fact that some species are heterothallic and that in all species the ascospores usually require a certain heat-treatment to stimulate them to germinate.

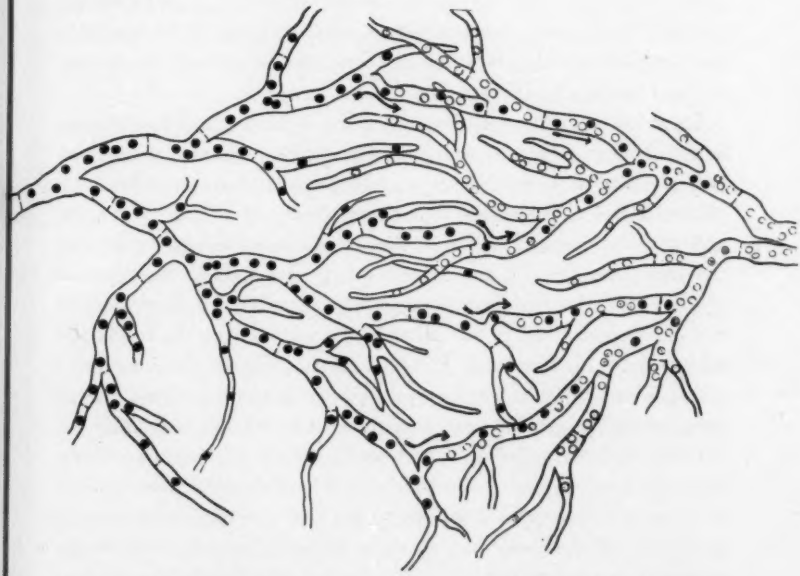

FIG. 1. Diagram showing how race S9 mycelium of *Neurospora tetrasperma* becomes miktohaplontic by nuclear migrations from S1.

Having briefly noted how one might group species of ascomycetes as to their inherent ability to fruit sexually, we may turn to a comparison of species in our Groups 2 or 3.

Just what is the fundamental difference between the 8-spored heterothallic *Neurospora sitophila* and the 4-spored totipotent

N. tetrasperma? Is the difference merely in the orientations of their nuclear spindles in the asci, and is this orientation a function of ascus shapes and dimensions, or is it a function of mutual sexual attractions and repulsions? An answer to these questions must distinguish exactly between what we have called facultative and obligate heterothallism. Not knowing the cytology of *N. tetrasperma* one must classify it as homothallic. Knowing that its mycelial cells are normally heterocaryotic and bisexual, the term homothallic is not applicable at all. The term facultative heterothallism was suggested to cover species like *N. tetrasperma* where one can separate mechanically the two component unisexual elements. For example, our tester races C4 and C8 were isolated by plating out small unisexual conidia. One could in this way obtain a collection of strains which would be of two sorts as to their reactions when paired.

Experiments with this species as well as with *Gelasinospora tetrasperma* and *Pleurage anserina* prove that whenever one grows two mycelia of opposite sex together from opposite sides of a plate culture anastomoses occur and these are followed by variable amounts of nuclear migrations.[3] We have recently repeated the experiments with our races Gel. 1 and Gel. 5. Every one of the 84 1-tip cultures obtained in the manner described in the paper just cited produced mycelia which gave rise to fertile perithecia. Furthermore 17 of the isolates were obtained from a transplant taken from the underside of the agar. This proves that nuclear migrations are not confined to surface hyphae.

Cook and Swingle [4] distinguished very clearly between those cells or phases in fungi carrying fused nuclei and those such as occur in *Agaricus* and *Puccinia* where the mycelial cells contain two unfused nuclei each. For the latter type they coined the term apalogamic phase.

Strasburger [5] proposed the terms haploid and diploid generations to apply particularly to phases in which the nuclei contain the single and double number of chromosomes respectively. He emphasized in several of his later papers the difference between

[3] The mechanics of sexual reproduction in *Neurospora*. Mycologia **27**: 418–438. 1935.

[4] Evolution of cellular structures. Bur. Plant Ind. Bull. **81**: 1–20. 1905.

[5] Histologische Beiträge zur Vererbungsfrage. Jahrb. Wiss. Bot. **42**: 1–71. 1905.

diploid cells and binucleate cells. The geneticists have also firmly fixed the terms triploid, tetraploid and poyploid in the literature as denoting relative chromosome numbers. *Neurospora tetrasperma* cells normally contain two kinds of nuclei as to their sex reaction but they are not diploid; they are multinucleate but not polyploid; they are heterocaryotic and miktohaplontic as Kniep used the latter term; they are bisexual in their reaction. Unisexual races of this species could be heterocaryotic and yet not be miktohaplontic. We should refer to the binucleate phase of a rust or mushroom as dicaryotic rather than diploid. Buller's term "diploidization" has a fine ring to it nevertheless.

If, as the result of hyphal anastomoses, nuclei of one or more kinds migrate from one mycelium into another of opposite sex so that there is a commingling of these several sorts one has not thereby hybridized two unisexual races (FIG. 1). It is only when two nuclei, one from each parent race, fuse in the ascus that one obtains a hybrid. Asci are the only structures in the whole life cycle that can express true hybridity. If one proposes the term prohybrid for a mycelium whose nuclear content has been added to through hyphal fusions and nuclear migrations, well and good. Hybridization is accomplished only when those nuclei fuse in an ascus or a basidium.

When races S1 and S9 are opposed in a plate culture, nuclei from S1 usually migrate down the lines of S9 hyphal growth. As pointed out elsewhere the direction and extent of this migration may depend not only on cultural conditions but possibly on the sexual attractions existing naturally between the two kinds of nuclei. One sees (l.c.[3] *pl. 40, A*) streaks of perithecia along certain coarse hyphae. It may be that the opening or pore present in a cross wall is more or less proportional to the diameter of the hyphal cell. In fully mature or aged hyphae the pores must be smaller or more nearly closed up. This could account for the difficulty one has in "spermatizing" old incipient perithecia. In certain matings (l.c.[3] *pl. 40, B*) nuclear migrations in one direction are limited to a certain band. The width of this band increases very slowly. One can not say that there is no overgrowth or mingling of hyphae, but under well regulated cultural conditions and choice of races one can easily prove

nuclear migrations where it is not possible to find evidence for a mycelial overgrowth.

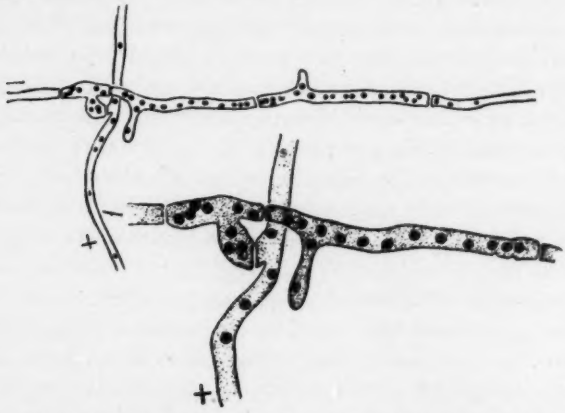

FIG. 2. Local miktohaplontic condition in heterothallic *Neurospora sitophila* resulting presumably from nuclear migrations through pores in the cross-walls. After Schönefeldt.

Köhler[6] working with mixtures of germinating monilioid conidia of *N. sitophila* tried in vain to unite vegetatively races of opposite sex. On the other hand Schönefeldt,[7] working with hyphal growth instead of germinating conidia, seems to have shown that although she saw no openings or other evidence of nuclear migrations where the +/− hyphae came into contact, in the tangle in some way a nuclear migration does occur very locally and this results in the development of fertile perithecia at that spot (FIG. 2). In our own work, reported elsewhere,[3] we were not able to prove in a limited number of experiments, nuclear migrations in mixed cultures of *N. sitophila*. One sees occasionally individual hyphae from one race growing along under the mycelium of the opposite sex. This would certainly provide opportunity for fertilization in various parts of a culture without the necessity for extensive nuclear migrations in wholly vegetative growth.

We have seen that in the facultatively heterothallic ascomy-

[6] Zur Kenntnis der vegetativen Anastomosen der Pilze. Planta **10**: 495–522. 1930.

[7] Entwicklungsgeschichtliche Untersuchungen bei *Neurospora tetrasperma* und *Neurospora sitophila*. Zeits. Induk. Abstam. Vererb. **69**: 193–209. 1935.

cetes, *Neurospora tetrasperma*, *Pleurage anserina*, and *Gelasinospora tetrasperma*, there is from the time the spores are delimited up to nuclear fusions in the asci some sort of attraction which tends to hold nuclei of opposite sex together in the same cells. This enables the totipotent mycelia to develop perithecia directly, that is without outside fertilization or spermatization by criss-crossing. If isolated unisexual races are grown together nuclear migrations follow anastomoses. This has been proved for cases when the unisexual races concerned were of *opposite* sex in their reactions. No one has as yet proved, however, that there are interchanges of nuclei when the races are of the *same* sex but differ in other genetic factors. When such experiments are performed we may have an answer that will throw further light on the nature of sex in these fungi; we shall know whether nuclear migrations result from something in addition to natural protoplasmic streaming.

As I see it today the main difference between facultative and obligate heterothallism is that in the former nuclei of opposite sex have a certain rather strong attraction for each other throughout the life cycle. This attraction is responsible more than anything else for the peculiar orientation of the nuclear spindles in the asci. In obligate heterothallic species like *Neurospora sitophila* this attraction is strong only at a certain stage of maturity. This would mean that if one should succeed in any way in obtaining a miktohaplontic mycelium, one in which the cells contain nuclei of opposite sex, he would obtain, on isolating hyphal tips from regenerated growth, only unisexual mycelia because of the strong tendency to split up. It remains to prove by careful experiments whether this can be done or not. If we assume that there is a sort of sexual attraction, the resultant direction the migrating nuclei take may depend on the relative sizes of the cross-wall pores of the two races. This does not exclude the possibility that the cytoplasm may also be a factor.

Of the five facultative heterothallic species which I have studied *Pleurage taenioides* and *P. anserina* seem to be less fixed as to their miktohaplontic nature. The basis for this conclusion is given in another place.[8]

[8] Spermatia and nuclear migrations in *Pleurage anserina*. Mycologia **28**: 284–291. 1936.

THE NEW YORK BOTANICAL GARDEN

STUDIES IN THE GENUS MYCENA. III.[1]

ALEXANDER H. SMITH

(WITH 3 FIGURES)

During the fall of 1935, with the aid of a grant from the Faculty Research Fund of the University of Michigan, the writer studied intensively the species of *Mycena* occurring along the coast of Washington, Oregon and northern California. After establishing head quarters at Lake Crescent, about twenty miles west of Port Angeles, Washington, trips were made to the Cape Flattery region, Lake Ozette, La Push, and up the Hoh River as well as back into the mountains around Olympic Hot Springs and Sol Duc Hot Springs. With the onset of cold weather during the first part of November, the writer moved south to the sand dune region between Florence and Reedsport, Oregon. During the first part of December the third and final location was made at Trinidad, California, a small hamlet a short distance north of Eureka. The weather for the most part was exceptionally cold and dry throughout the entire coastal area.

The species in the *Mycena* flora which were most abundant were *Mycena tenax*, described below, *M. aurantiomarginata* (Fries) Quél., *M. galopoda* (Fries ex Pers.) Quél. and *M. amicta* (Fries) Quél. Other very interesting species are: *Mycena juncicola* (Fries) Gill., *M. scabripes* Murr., *M. elegans* (Fries ex Pers.) Quél. and *M. trachyspora* Rea. The last three were rather abundant under pure stands of redwood, a situation which was a distinct surprise to the writer.

In addition to the western material, certain species and collections from central and eastern United States are also included at this time. The collection numbers and the photographs are the writer's unless otherwise stated. The specimens have been deposited in the Herbarium of the Univeristy of Michigan.

The writer is particularly grateful to Prof. S. M. Zeller of

[1] Papers from the Department of Botany and the Herbarium of the University of Michigan, no. 568.

Oregon State Agricultural College, Corvallis, Oregon, for helpful suggestions and for courtesies extended to him while he was located in Oregon, and to Mr. Harold E. Parks of Trinidad, California, whose intimate knowledge of the northern coastal area of California contributed in a very large measure to the success of the writer's visit.

Mycena nodulosa sp. nov. (FIG 3: 1–3).

Pileus 1–3.5 cm. latus, tenuis, conico-campanulatus, demum umbonatus, fuscus vel griseus, demum pallidus, canus demum politus; lamellae latae, confertae, rufo-maculatae, adnexo-adnatae, pallidae; stipes 6–10 cm. longus, (1)2–3 mm. crassus, radicatus (4–8 cm.), dense pubescens, dorsum fuscus, sursum pallide griseus; sporae globosae, hyalinae, 6–7.5 μ, nodulosae; cystidia 60–80 × 10–12 μ, fusoideo-ventricosa, leva vel incrassata; superficies pilei e cellulis basidiiformibus unistratosis constans.—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope Lake Crescent, Washington, Oct. 6, 1935, A. H. Smith, *n. 2999*.

Pileus 1–3.5 cm. broad, conic, campanulate or expanded and with a conic umbo, surface at first hoary from projecting cystidia and appearing very finely pubescent under a lens, soon glabrous, moist, striate to the disk, "fuscous" [2] to black on the umbo, margin dark or light watery gray, fading to a pallid sordid gray; flesh soft and pliant, pale fuscous, very thin, taste and odor not distinctive, in extreme age sometimes staining reddish brown; lamellae broad, moderately close, deeply adnexed to broadly rounded and depressed adnate, whitish to glaucous gray, spotted brownish in age; stipe 6–8 cm. × (1)2–3 mm., with a pseudorhiza 4–8 cm. long, fuscous at first, becoming pale gray to whitish above, evenly covered by a white pruinose-pubescent covering of cystidia, pliant, with a sharply differentiated cartilaginous rind, hollow; spores globose, hyaline, 6–7 μ, with aculae 2–3 × 1.5 μ scattered over the surface, staining pale yellowish with iodine in chloral hydrate; cystidia numerous on sides and edges of the gills, 60–80 × 10–12 μ, usually with incrusted apices, unbranched, fusoid-ventricose; basidia four-spored; pileus trama corticated by a pallisade layer of clavate basidia-like cells measuring 18–22 × 8–9 μ, elongated cystidia 100–150 × 8–10 μ projecting from this layer at intervals, the remainder of compact floccose-filamentose tissue.

This species is easily distinguished by the pallisade layer of small basidia like cells forming the surface of the pileus. Because

[2] All names of colors within quotation marks are taken from R. Ridgway, Color Standards and Color Nomenclature, 1912.

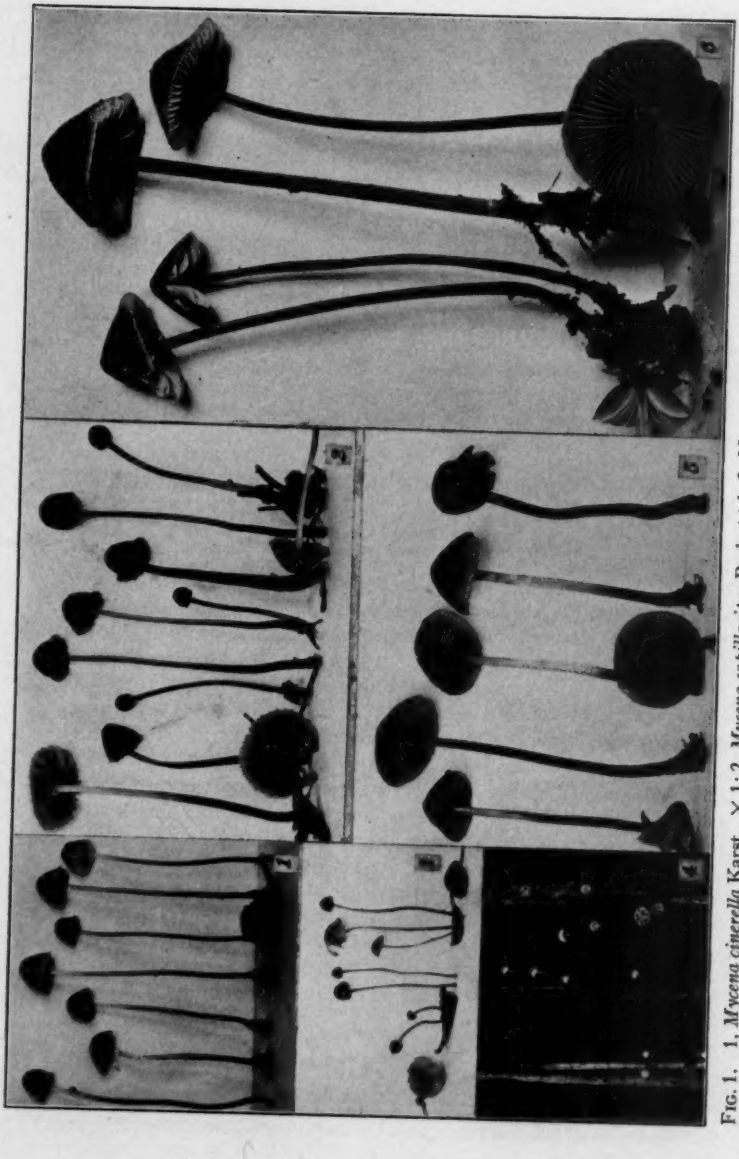

FIG. 1. 1, *Mycena cinerella* Karst., × 1; 2, *Mycena capillaripes* Peck, × 1; 3, *Mycena oregonense* Smith, × 1; 4, *Mycena juncicola* Fries, × 1; 5, *Mycena auranhiomarginata* Fries, × 1; 6, *Mycena trachyspora* Rea, × 1.

of the collapsible nature of these cells they are difficult to demonstrate in dried material. The incrusted cystidia are very like those of *Mycena Cooliana* Oort which is said to be without a pseudorhiza. From *Mycena Meulenhoffiana* Oort it differs in its tough rather flexible stipe and incrusted cystidia. Judging from the description, *Mycena bryophila* Voglino is readily separable because of its glabrous stipe.

Mycena oregonensis sp. nov. (FIG. 1: 3).

Pileus 2–10 mm. latus, obtuse conicus vel convexus, glaber, luteus, fragilis; lamellae distantes vel subdistantes, angustae, late adnatae, brevissime angulatim decurrentes, acie lutea; stipes 1–3 cm. longus, 0.5–0.7 mm. crassus, pileo concolor; sporae 7–8 × 2.5–3 μ, anguste ellipsoideae, apice acuminatae; cystidia fusoideo-ventricosa, leva, 35–45 × 10–12 μ.—Specimen typicum in Herb. Mich. conservatum: Legit prope Lake Tahkenitch, Oregon, Nov. 21, 1935, A. H. Smith, n. *3586*.

Pileus 2–10 mm. broad, obtusely conic to convex, faintly hoary at first, soon polished, moist, "capucine yellow" on the disk, "deep chrome" toward the faintly striate margin, opaque after loosing moisture, colors hardly fading, edge entire or somewhat broken; flesh thin, brittle, odor and taste not distinctive; lamellae distant to subdistant, at first sometimes appearing close, narrow, broadest at point of attachment, adnate, developing a rather distinct decurrent tooth in age, "massicot yellow" or appearing whitish, edge "deep chrome"; stipe 1–3 cm. × 0.5–0.7 mm., concolorous with the pileus or paler yellow, evenly covered by a faint yellowish pruinose-pubescence, inserted on needles by a yellow strigose base; spores 7–8 × 2.5–3 μ (3186), 8–10 × 3.5–4 μ (No. *3018*), staining pale yellowish with iodine in chloral hydrate, narrowly ellipsoid, apex acuminate; basidia four-spored in No. *3186* and *3421*, two-spored in *3018*; cystidia 35–45 × 10–12 μ, fusoid-ventricose, smooth, filled with a bright sulfur yellow substance, numerous on the gill edge, scattered on the sides; pileus trama with a thin pellicle over the surface, beneath this a layer of enlarged cells filled with a bright yellow substance, central portion floccose, subhymenium with a few greatly enlarged cells with or without yellow contents.

Gregarious on needles in river bottom land, Hoh River, Washington, Oct. 7 (*3018*), and under spruce at Lake Tahkenitch, Oregon, Nov. 11 (*3421*) and Nov. 21, 1935 (*3586*). In consistency and the bright color of the dried specimens this species resembles *Mycena strobilinoidea* Peck. It is also closely related

FIG. 1. 1, *Mycena cinerella* Karst., × 1; 2, *Mycena capillaripes* Peck, × 1; 3, *Mycena oregonense* Smith, × 1; 4, *Mycena juncicola* Fries, × 1; 5, *Mycena aurantiomarginata* Fries, × 1; 6, *Mycena trachyspora* Ren., × 1.

to *Mycena acicula* Fries from which it is readily separated by the bright yellow gill edge and the smaller spores. *Mycena aurantiidisca* Murr. is a closely related species with abundant fusoid-ventricose cystidia on the sides and edges of the gills (37–44 × 8–11 μ), and broadly ellipsoid spores which measure 7–8 × 4–5 μ. The species described by Kauffman (**9**) under the name *Mycena aurantiidisca* Murrill is characterized by the absence of cystidia on the sides of the gills, the narrow lanceolate spores which measure 6–8 × 2.5–3 μ, and the glandular hairs over the surface of the pileus and stipe. It is very likely that this species is also characterized by a pale yellow gill-edge since Kauffman describes the sterile cells as having a pale yellow content. Kauffman's fungus differs from *Mycena oregonensis* in the glandular covering of pileus and stipe, in the duller colors of the dried specimens, and the lack of cystidia on the sides of the gills. It is here considered to be an undescribed species and named as follows:

Mycena siskiyouensis sp. nov.

Pileus 3–7 mm. latus, membranaceus, conico-campanulatus, subumbonatus, aurantiacus vel saturate luteus, demum pallide citrinus, striatulus, pubescentia stipiti similis minute glanduloso puberulus; lamellae adnatae, angustae, subdistantes, pallidae; stipes 1.5–3 cm. longus, 0.5 mm. crassus, aurantiacus vel pileo concolor; sporae lanceolatae, leves, 6–8 × 2.5–3 μ; cystidia nulla; cellulae aciei lamellarum 32–35 × 7–9 μ, ventricosae, apice obtusae.—Specimen typicum in Herb. Mich. conservatum: legit prope Siskiyou National Forest, Takilma, Oregon, Nov. 30, 1935, C. H. Kauffman.

Mycena tenax sp. nov. (FIG. 2: 1 and FIG. 3: 4–5).

Pileus 1–3 cm. latus, ovoide vel convexus, demum obtuse conicus vel umbonatus, lubricus vel subviscidus, politus, fuscus demum griseus, striatus, sapore farinaceo-rancidus; pellicula separabilis et tenax; lamellae confertae, angustae, adnatae, pallidae; stipes 5–7.5 cm. longus, 2–5 mm. crassus, fuscus vel pallide griseus, viscidulus; sporae 6.5–8 × 3.5–4 μ, anguste ellipsoideae; cystidia 60–70 × 8–12 μ, acuminata.—Specimen typicum in Herb. Univ. of Mich. conservatum: Legit prope La Push, Washington, Oct. 25, 1935, A. H. Smith, n. *3325*.

Pileus 1–3 cm. broad, oval to convex at first, in age broadly conic or obtusely umbonate, disk flattened or slightly depressed at maturity, lubricous to subviscid, glabrous, at first "fuscous" to "hair brown" with a pale grayish margin, in age pale watery gray and striate to the abrupt translucent disk, opaque when faded and pale or dark ashy gray, with a thick tenacious separable pellicle;

flesh pliant, tough, pallid; odor and taste strongly rancid farinaceous or somewhat resembling that of raw cucumber, very pronounced; lamellae close, narrow (2–2.5 mm.), adnate or with a slight tooth, white, becoming grayish in age, edge even and pallid to grayish; stipe 5–7.5 cm. × 2–2.5 mm., concolorous with the pileus, pruinose above, white strigose at the base, equal, hollow, tenacious, subviscid; spores 6.5–8 × 3.5–4 μ, narrowly ellipsoid, pointed at one end, staining pale bluish gray with iodine in chloral hydrate; basidia four-spored; cystidia scattered on the sides of the lamellae, 60–70 × 8–12 μ, narrowly fusiform with a sharp acuminate point, some with thickened walls, cystidia on the gill edge clavate and with finger-like prolongations, gelatinizing as in *Mycena vulgaris* Fries; pileus trama with a typical thin subgelatinous pellicle over the surface, below this a pseudoparenchymatous layer of nongelatinous inflated hyphal cells, beneath this a layer of gelatinizing hyphae 75–120 μ or more thick, the remainder of typical floccose-filamentose tissue.

Densely gregarious under second growth fir, La Push, Washington, Oct. 25, 1935 (*3325*); under dense pine, Big Creek, Lincoln County, Oregon, Nov. 6 (Zeller and Smith, Zeller *9307*); Lake Tahkenitch, Oregon, under spruce, Nov. 10 (*3409*), Nov. 11 (*3433*); Siltcoos Lake, Oregon, Nov. 13 (*3449* and *3456*); Ada Station, Oregon, Nov. 16 (*3503*); and Trinidad, California, under redwood, Dec. 11, 1935 (*3936*). This species fruited in great abundance along the Pacific Coast from La Push to Trinidad, California, during the fall of 1935. In the sand dune region around Siltcoos Lake and Lake Tahkenitch literally thousands of the fruit-bodies were found in large patches every where under the conifers. The species is very closely related to *Mycena quiniaultensis* Kauff., Smith (**15**) which it resembles in color, size, consistency, spore characters and in having similar cystidia on the sides of the gills. It differs in having a gelatinous gill edge, a thick separable pellicle composed of three distinct layers of tissue, a glassy appearance at maturity, and a very disagreeable taste. Cleland (**2**) has described a species, *M. subvulgaris* which might be close to *M. tenax*, but he does not give any information concerning either the taste or the nature of the pellicle. In addition, he describes the stem of *M. subvulgaris* as being very glutinous and the cap as darker than in *M. vulgaris*.

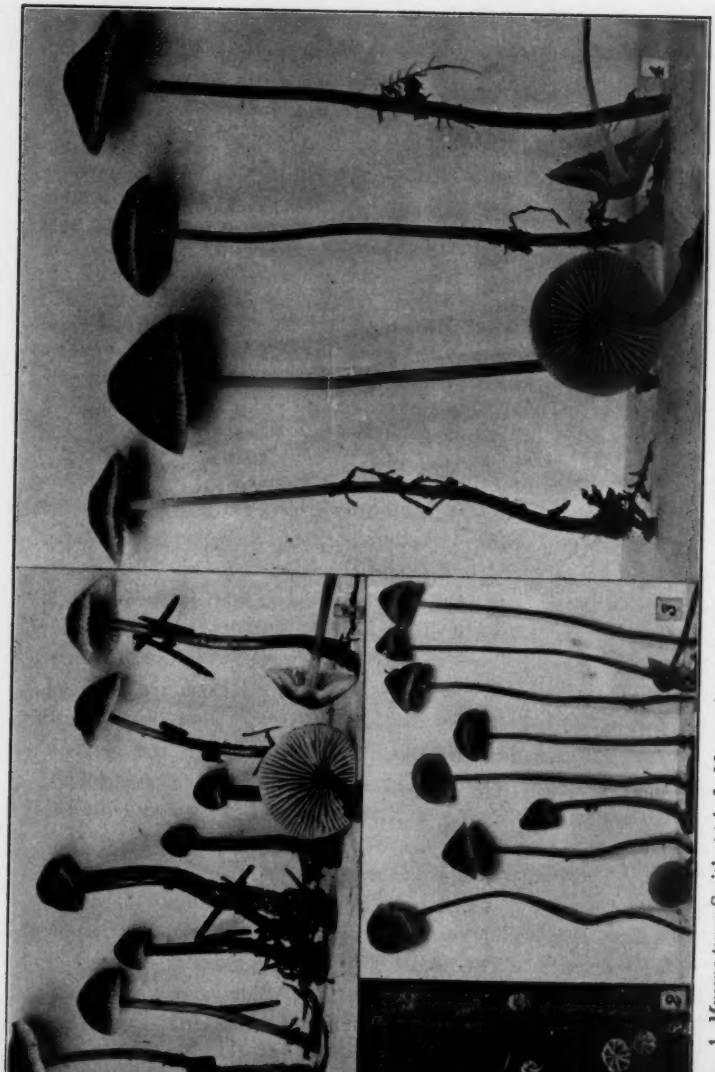

FIG. 2. 1, *Mycena tenax* Smith, × 1; 2, *Mycena juncicola* Fries, × 2; 3, *Mycena amicta* Fries, × 1; 4, *Mycena elegans* Fries, × 1.

MYCENA ADONIS (Fries ex Bull.) Quél.

Pileus 5–12 mm. broad, conic to campanulate, moist, "scarlet" when fresh, fading to orange or yellowish orange before losing moisture, hygrophanous, "orange buff" when moisture has escaped, margin becoming striatulate at maturity and somewhat wavy in age; flesh thin, fragile, odor or taste not distinctive; lamellae subdistant, narrow, somewhat adnate or attached by a tooth, yellowish or tinged incarnate, margin paler or concolorous with the sides; stipe 2–4 cm. × 1–2 mm., equal, fragile, at first pruinose, polished in age, pale yellow to white, base often sordid yellow or brownish in age; spores 6–7 × 3 μ, smooth, hyaline, remaining hyaline when treated with iodine in chloral hydrate; cystidia abundant on sides and edges of the lamellae, hyaline, smooth, fusoid-ventricose, 40–50 × 9–15 μ; pileus trama with a thin pellicle over the surface, beneath this a narrow region of slightly enlarged cells, the remainder of floccose tissue.

Gregarious under spruce and fir, Makah Indian Reservation, Washington, Sept. 18 (*2490*); Lake Ozette, Washington, Sept. 25 (*2597*); La Push, Washington, Oct. 25 (*3332*); and Oric, California, Dec. 2, 1935 (*3711*). The brilliant scarlet colors and abundant cystidia are the most reliable characters. *M. adonis* differs from *Mycena roseipallens* Murr. in the narrower spores, more brilliant and conic pileus, habitat on needle beds, and in its consistently smaller size. When dried carefully, fruit-bodies of *M. adonis* keep their bright colors whereas those of *M. roseipallens* become dull reddish brown.

MYCENA AMICTA (Fries) Quél., sensu Josserand (7). (FIG. 2: 3.)

Pileus 5–10 (15) mm. broad, obtusely conic, becoming convex with a conic umbo at times, faintly pruinose at first, soon glabrous and lubricous to subviscid, pellicle separable and tenaceous, when young nearly "olivaceous black (1)" on the disk and "light mineral gray" on the margin, often with a strong aeruginous to bluish tint, soon fading to near "wood brown" or "avellaneous" on the disk and near "tilleul buff" on the margin, at times the disk may be tinted vinaceous gray; flesh thin, cartilaginous, odor and taste mild; lamellae close, narrow, narrowly adnate, whitish, becoming pale avellaneous; stipe 4–8 cm. × 1–1.5 mm., sordid brownish gray, hoary from a dense pruinose-pubescent covering, color beneath a dark greenish blue at first but soon fading to sordid brownish gray, base slightly rooting and covered by bright blue fibrils; spores 7–9 × 4–5 μ, narrowly ellipsoid, smooth; cystidia

FIG. 2. 1, *Mycena tenax* Smith, × 1; 2, *Mycena juncicola* Fries, × 2; 3, *Mycena amicta* Fries, × 1; 4, *Mycena elegans* Fries, × 1.

on the gill edge only, 30–40 × 4–5 μ, narrowly fusoid and acuminate; pileus trama homogeneous below a thick gelatinous pellicle.

Densely gregarious on needles, Lake Crescent, Washington, Sept. 20 (*2515*), Sept. 21 (*2525*), Sept. 24 (*2581*), and Oct. 22 (*3277*); Lake Tahkenitch, Oregon, Nov. 21 (*3584*); Trinidad, California, Nov. 30 (*3675*) and Dec. 1 (*3703*); Oric, California, Dec. 3, 1935 (*3738*). The fungus which Rea (**13**) has named *Mycena iris* var. *caerulea* was collected sparingly on decaying conifer logs (La Push, Washington, Oct. 25, No. *3330*, and along the Mad River, California, Dec. 10, 1935, No. *3917*). The more conspicuous pruinosity at the apex of the stipe, the bright blue colors of the pileus, and the larger size are the most striking differences. It apparently is a robust form of *M. amicta*. It seems clear to me, after studying numerous variations of *M. amicta* along the Pacific Coast, and of *Mycena subcaerulea* (Peck) Sacc. in the region of the Great Lakes, that collections of a *Mycena* having bluish or aeruginous tints at first in some portion of the fruiting body, a thick gelatinous pellicle, a rather cartilaginous-flexible consistency, and a densely pruinose stipe can nearly always be properly referred to one of these two species. If the spores are ellipsoid and measure 7–9 × 4–5 μ, the species is properly placed in *M. amicta*. If the spores measure 7–8 × 6–8 μ and are globose to subglobose, the collection should be placed in *M. subcaerulea*. All measurements should be made on spores from four-spored basidia. The spores of both species turn pale bluish gray with iodine in chloral hydrate.

A study of the type specimens of *Mycena subcaerulea*, *Mycena cyaneobasis* Peck, and *Mycena cyanothrix* Atk. has shown that all are simply forms of one species, properly designated as *Mycena subcaerulea* (Peck) Saccardo. *Mycena caesiialba* Murrill differs from all in this group in having narrowly fusoid cystidia on the sides and edges of the lamellae which measure 30–49 × 4–8 μ, and in its spores which are broadly ovoid and measure 7–9 × 6–7 μ. The basidia are four-spored.

The writer has collected a minute form of *M. subcaerulea* in New York (Warrensburg, Sept. 14, 1934, No. *905*) with a pileus 2–5 mm. broad, and resembling *Mycena corticola* Fries very closely in stature. The pileus was watery gray with conspicuous darker

striations. The base of the stipe was strigose with bright blue hairs. Since the fundamental characters are identical with those of *M. subcaerulea* it is best considered to be merely a form of that species. Similar depauperate forms have been found in other species, *Mycena alcalina* Fries in particular.

MYCENA AURANTIOMARGINATA (Fries) Quél. (FIG. 1: 5).

Pileus 8–20 mm. broad, obtusely conic to campanulate, becoming nearly plane in age, faintly pruinose, soon polished and lubricous, when moist dark olive fuscous on the disk and the margin bright orange tinged with fuscous or the disk "orange-citrine" to "medal bronze" and the margin "cadmium orange," striate, not hygrophanous, fading to pallid olive brown with an orange tinge or near "naples yellow," somewhat plicate in age; flesh thin, rather pliant, odor and taste not distinctive; lamellae narrow, becoming broad in age, close, bluntly adnate or with a decurrent tooth, pallid to grayish olive on the sides, edges bright "cadmium orange"; stipe 3–6 cm. × 1.5–2 mm. rigid and cartilaginous, "buffy brown" to "medal bronze" with an orange tinge, glabrous, orange pruinose above, base densely strigose with "cadmium orange" hairs; spores 7–9 × 4–5 μ, ellipsoid, smooth, staining faintly bluish gray with iodine in chloral hydrate; cystidia abundant on the sides and edges of the lamellae, 28–36 × 7–9 μ, clavate, the apices sparsely to densely echinulate, filled with a bright orange substance; pileus trama with a thin pellicle over the surface on which are found scattered cystidia similar to those on the gills, beneath this is a region of enlarged cells, the remainder is filamentose and homogeneous.

Widely scattered to gregarious under spruce and fir, Lake Ozette, Washington, Sept. 25 (*2595*); Lake Crescent, Oct. 10 (*3080*); Joyce, Oct. 11 (*3107*); Lake Crescent, Oct. 22 (*3283*); Joyce, Washington, Oct. 28 (*3393*); Lake Tahkenitch, Oregon, Nov. 11 (*3435*); Siltcoos Lake, Oregon, Nov. 13, 1935 (*3455*). One collection was obtained at Trinidad, California, Dec. 2, 1935 (*3725*). During the early part of the season only a few scattered fruiting bodies were found at a time on the needles under fir and hemlock. Later, particularly in the second growth fir around Joyce, Washington, it grew in dense troops. This is clearly the species described and illustrated by Konrad & Maublanc (11). As they have pointed out, the color of the pileus varies greatly, but the species can always be recognized by the bright orange

edging of the lamellae. The color of the gill edge is very comparable to that of bright orange pilei of *Mycena leajana* Berk., and fades but little even in extreme age.

MYCENA ELEGANS (Fries ex Pers.) Quél. (FIG. 2: 4).

Pileus (4–10) 15–25 (35) mm. broad, convex to obtusely conic, becoming broadly campanulate to subumbonate in age, moist, at first densely white pruinose, soon polished, subhygrophanous, "dark olive" when fresh, margin "light chalchedony yellow" fading to a sordid olive gray with a whitish margin before losing moisture, pale "avellaneous" to pale olive gray when faded, striate to the disk when moist, margin entire; flesh watery gray, fragile, odor and taste not distinctive; lamellae narrow, moderately close to subdistant, ascending adnate, dull pale olive gray, margin "pale green yellow," at times staining sordid purplish brown in age; stipe 4–9 cm. × 1–2 mm. or 10–12 cm. × 2–3 mm. equal or base slightly enlarged, base densely strigose with "pale green yellow" hairs, faintly pruinose above, polished in age, pale or dark olive gray with a decided yellow tinge, apex at times pale yellow, tubular, fragile, in age tending to become dull reddish brown; spores 7.5–9 × 4–4.5 μ, ellipsoid, smooth, staining pale bluish gray with iodine in chloral hydrate; cystidia on sides and edges of the lamellae, 28–33 × 7–10 μ, clavate, with echinulate apices; pileus trama with a thin adnate subgelatinous pellicle, below this a region of inflated cells irregularly arranged, the remainder of floccose filamentose tissue.

Scattered to gregarious under cedar at Siltcoos Lake and Lake Tahkenitch, Oregon, Nov. 13–19, 1935 (*3453*, *3508*, *3546*), and under redwoods in Praire Creek State Park, Oric, California, Dec. 2–4, 1935 (*3714*, *3709*, *3757*). Konrad (**10**) and other investigators in Europe have referred *M. elegans* to *M. aurantiomarginata* as a synonym. As pointed out above, my collections of *M. aurantiomarginata* compare well with the description of that species by Konrad and Maublanc (**11**). It is obvious, however, that their description does not apply to the larger, darker species with the pale yellow colors on the gill edges and stipe. Fries (**4** and **5**) described the gill edge of *M. aurantiomarginata* as "aurantia" and "aurantiis" whereas the edge of the gills in *M. elegans* is described as "crocea" and "croceis." Wharton (**17**) in discussing Fries' nomenclature of colors includes the term croceus or saffron yellow in the group of pale yellows such as sulphur

yellow, straw color, etc. and aurantius is classed with the orange yellows and described as being a full orange, cadmium orange. Using this interpretation of the Friesian color terms, the American collections described above fall readily into two groups which are very easily recognized and which have not been observed to intergrade. It thus seems advisable to recognize both as distinct species. Their cystidia are alike, but they differ in consistency. *M. aurantiomarginata* is not as fragile as *M. elegans*. As shown in the photographs, there is considerable difference in stature but this must be used with caution. The dark olive-black ground color of *M. elegans* reminds one somewhat of *M. alcalina* Fries whereas that of *M. aurantiomarginata* is bronze tinged with gray. In addition, in wet weather the flesh of *M. elegans* has a rather pronounced tendency to stain reddish brown in both the cap and stipe.

The writer (**16**) recently described under the name *Mycena elegans* (Pers.) Quél. a fungus commonly found on oak leaves and humus in the vicinity of Ann Arbor, Mich. This differs from the typical form in the densely white strigose base of the stipe, the fuscous disk and pale grayish margin of the pileus, and pallid gills which sometimes lack the yellow edging. It grades imperceptibly into the species and should be considered only as an ecological form.

MYCENA CAPILLARIPES Peck (FIG. 1: 2).

Since publishing an account (**15**) of this species, it was collected abundantly in the Adirondack Mts. of New York (*691*, *701*, *713*, *724*, *834*) during the fall of 1934. During the same season Prof. E. B. Mains collected it at Marquette and Little Lake, Michigan (E.B.M. *34–166*, *34–191*, *34–194*). During the season of 1935 it was found scattered on mossy slopes in oak-hickory groves near Ann Arbor (*1345*, *1418*, *1649*), in dense troops covering large areas in a spruce plantation (*1369*, *1616*, *1741*, *1742*) at Ann Arbor, and fairly abundant under Douglas Fir in the vicinity of Lake Crescent, Washington (*2532*, *2509*, *2548*, *2743*). The Ann Arbor collections have all been characterized by two-spored basidia or a variable number, two-, three-, and four-spored all on the same pileus. The spores of the two-spored form usually measure 10–12.5 × 5–6.5 μ, but often larger spores (11–14

× 6–8 μ) are found. The collections from the Adirondacks, northern Michigan and Washington were all four-spored; the spores from deposits measuring 8–10 × 4–5 μ or 7–9 × 3–4 μ in the Adirondack specimens. Two distinct color forms were present in the collections from the spruce plantation (*1741, 1742*). In No. *1741* the pilei were "light seal brown" or "seal brown" on the disk with a "vinaceous-brown" margin. In some the disk was "dark livid brown" to nearly "fuscous." In age the colors faded to "cinnamon drab" or sordid grayish brown. In no. *1742* the colors were "Prussian red" to "dark indian red" becoming "vinaceous-fawn" at maturity or gray with a faint vinaceous tinge. The basidia of both were bispored. Each form was always found in a definite localized area. The odor which is one of the striking characters of this small fungus, was very weak to almost lacking in the Washington material. Here again, all other characters placed the fungus in this species. The spores of all of the collections stain faintly bluish gray with iodine in chloral hydrate.

MYCENA CINERELLA Karst. (FIG. 1: 1).

Pileus (3)5–10 mm. broad, obtusely conic, striate to apex, dark gray over the disk and striae, remainder paler, margin whitish, surface glabrous and lubricous, margin entire, appressed against the stem at first; flesh thin, cartilaginous and tough, odor and taste rancid and disagreeable; lamellae moderately close to subdistant, moderately broad, broadly adnate-decurrent, pale gray, edge whitish; stipe (2.5)3–5 cm. × 0.7–1.5 mm. equal, base slightly enlarged and only slightly strigose, pallid gray or whitish, always pallid above, faintly pruinose, cartilaginous; spores 6.5–8 × 3.5–4 μ, pointed at one end, staining faintly yellowish with iodine in chloral hydrate; basidia four-spored; cystidia on edge only, clavate, the apex set with minute rod-like projections, 24–28 × 5–8 μ, pileus trama with a thin pellicle over the surface and a region of inflated cells beneath it, the remainder of floccose-filamentose tissue.

Gregarious on needles under pine, Marquette, Michigan, Sept. 12, 1934 (E. B. Mains *34–174*); under bishop pine, Trinidad, California, Dec. 10, 1935 (*3918*). This is apparently the first report of typical material of the species from North America. It may have been found previously and placed in the genus

Omphalia where it would be near *O. picta* Fries. The Michigan and California collections are similar to material received from England.

MYCENA EXCISA (Fries ex Lasch) Gill.

Pileus 2–3.5 cm. broad, broadly conic to nearly plane, dry, densely white pruinose at first, soon polished, "fuscous" or darker on the disk, margin paler and tinged with brown, fading to fuscous gray in age, margin opaque when moist, radially rugulose at maturity and entire; flesh thin, tough and cartilaginous, grayish brown, odor and taste none; lamellae broadly and deeply adnexed, ventricose and broad, subdistant to close, white, becoming faintly fuscous or grayish, edge white or grayish; stipe 3–4.5 cm. × 2–3 mm., short and cartilaginous, tough, pale fuscous below, pallid above, evenly white pruinose at first, polished in age, often compressed and twisted; spores 8–10 (12) × 6–6.5 μ, broadly ellipsoid, smooth, staining faintly bluish gray with iodine in chloral hydrate; cystidia abundant to scattered on the sides of the gills, 50–65 × 10–12 μ, fusoid-ventricose, those on the gill edge 30–45 × 10–12 μ, fusoid ventricose or with apices branched; basidia four-spored; pileus trama with a thin adnate pellicle over the surface, a region of inflated cells beneath it and the remainder of floccose-filamentose tissue.

Gregarious on humus in mixed woods, Crescent Beach, Washington, Sept. 22, 1935 (*2544*); and scattered to subcespitose on very decayed conifer logs, Crescent Beach, Sept. 24 (*2574*) and Oct. 12 (*3113*). The cystidia, the broad and deeply adnexed gills, the short stipe, and the tough cartilaginous consistency characterize the species.

MYCENA FILIPES (Fries ex Bull.) Quél.

Pileus (5) 10–20 (25) mm. broad, obtusely conic, campanulate, or with a flaring margin and a long obtuse umbo, the buttons cylindric to oval, at first with a faint bloom, glabrous, umbo "fuscous" at first, fading to "benzo brown" margin watery gray or paler, gradually fading to whitish gray with a pale brownish gray disk, striate when moist, sulcate at times in age, margin entire; flesh thin, taste mild, odor none, rather fragile; lamellae close to scarcely subdistant, narrow, adnate, pallid brownish drab or a darker gray, edge whitish, projecting to the edge of the pileus; stipe (5) 8–12 (15) cm. × 1–2 mm. pale fuscous, the apex often bluish black at first, fading to pallid gray or pallid watery white

above, becoming grayish and finally dark brownish drab below, hoary, translucent in age, equal, straight or twisted, very brittle, base rooting slightly and white strigose; spores 7–9 × 4–5 μ, narrowly ellipsoid, staining pale bluish gray with iodine in chloral hydrate, smooth; basidia four-spored; cystidia 35–44 × 12–22 μ, echinulate, with a large globose head and a narrow pedicel, rare on the sides, forming a broad sterile band on the edge.

Gregarious under pine, Florence, Oregon, Nov. 14 (*3473*) and Nov. 20, 1935 (*3563*). This species was collected in great abundance and ample opportunity was found to study its variations. *Mycena iodiolens* Lundell and *M. atroalboides* Peck are its nearest relatives. *M. iodiolens* can be readily distinguished by the rather distinct sterile margin of the pileus which tends to become somewhat frayed at times as well as by the pronounced odor of iodoform which develops after the fruiting bodies are collected. In all of my collections of *M. filipes* the gills project to the edge of the pileus and are broader as well as more distant than those of *M. iodiolens*. *Mycena atroalboides* differs in the more expanded pileus with a characteristically flattened umbo, in its tendency to stain reddish brown where bruised or broken, and in its short stem when not growing in deep moss such as sphagnum. House (6) has published a description and illustration of the two spored form of *M. filipes* based on Atkinson's material. Beardslee (1) states that it is common in North Carolina and Ohio, but the writer has rarely collected it in Michigan.

MYCENA GALOPODA (Fries ex Pers.) Quél.

Pileus 5–25 mm. broad, conic to conic-campanulate, at first with a hoary sheen, "fuscous-black" on the disk at maturity, remainder abruptly paler and usually watery gray to whitish, striate to disk when moist, margin entire; flesh thin, soft, fragile, no distinctive odor or taste; lamellae subdistant, narrow, adnate, whitish or gray, usually darker in age, edge whitish or gray; stipe 4–8 (11) cm. × 1–2 mm., dark blackish brown below, paler at the apex, fragile, glabrous except for the white strigose base, exuding a white milk-like juice when broken; spores 9–12 (13) × 5–6 μ, smooth, staining yellowish with iodine in chloral hydrate; basidia four-spored; cystidia abundant on the sides of the gills, 70–90 × 10–14 μ, fusoid-ventricose or the tip sharply acuminate, those on the gill edge shorter and often forking at the apex; pileus trama with a thin pellicle over the surface and a region of

inflated cells irregularly arranged beneath it, the remainder homogeneous.

Gregarious on needles and debris under Douglas Fir, spruce and redwood, Boulder Creek, Olympic Hot Springs, Washington, Oct. 15 (*3151*); Sol Duc Hot Springs, Washington, Oct. 17 (*3209*); Lake Crescent, Washington, Oct. 18 (*3215*); La Push, Washington, Oct. 23 (*3335*); Siltcoos Lake, Oregon, Nov. 13 (*3454*); Florence, Oregon, Nov. 14 (*3471*); Trinidad, California, Nov. 30 (*3668*) and Nov. 30 (*3677*); Oric, California, Dec. 2 (*3724*) and Dec. 3, 1935 (*3737*). In California this species fruited abundantly around the bases of old redwood stumps as well as on the debris at the bases of living trees. In robust fruiting bodies such as those usually found around the redwoods, the milky juice was copiously exuded from any injured portion, but in smaller individuals it could frequently be demonstrated only at the base of the stipe. Beardslee (1) reports the species as common during the summer around Ashville, North Carolina.

MYCENA JUNCICOLA (Fries) Gill. (FIG. 1: 4 AND FIG. 2: 2).

Pileus 1–3 mm. broad, conic to convex or broadly convex, at times with a slight papilla, usually uneven or rugulose around the disk, glabrous, moist and shining, flesh opaque, sulcate striate to the disk in fresh specimens, disk tinged purplish to vinaceous or grayish vinaceous, margin paler and whitish; flesh membranous, fragile, odor and taste not distinctive; lamellae distant, broadly adnate, narrow or moderately broad in large caps, pale grayish vinaceous, edge whitish to gray; stipe 3–5 (10) mm. long, filiform, glabrous above, hyaline, grayish white or grayish vinaceous, attached to the substratum by a flat vinaceous brown plate ½ to 1 mm. broad; spores 9–11 × 5–6 μ, staining pale yellowish with iodine in chloral hydrate basidia four-spored; cystidia numerous on the gill edge, 28–34 × 7–10 μ, clavate with echinulate apices, not present or very rare on the sides.

Densely gregarious to subcespitose on sedge culms, at the bases of the clumps on the sheaths or on old exposed roots, Lake Tahkenitch, Oregon, Nov. 17, 1935 (*3512*), Nov. 18 (*3545*) and Nov. 24 (*3613*). This species is most closely related to *Mycena pterigena* Fries which it resembles in consistency, stature, broad distant gills, cystidia and spores. It is easily distinguished by the duller reddish vinaceous colors, the pallid gill edge, the

characteristic flat plate at the base of the stipe, and the shorter grayish vinaceous stem. The stipe separates from the pileus fairly easily in mature individuals and in all probability the species should be classed in the group Insiticia as defined by Kühner (**12**). Free hand sections however do not show a sharply distinct zone of narrow hyphae at the apex of the stem.

MYCENA MILITARIS Karst.

Pileus 3–4 mm. broad, conic-campanulate, in age with a sharply conic umbo, small forms often papillate, glabrous, viscid, "fuscous" to blackish on the disk, "hair brown," "wood brown," "avellaneous," or pale gray on the margin, pellucid striate when moist, sulcate at maturity, in age pallid cinereous with a blackish umbo; lamellae gray, subdistant, bluntly adnate or with a small decurrent tooth, moderately broad, edge whitish; stipe 2.5–3 cm. × 1 mm. yellowish gray below, paler above, pallid over all and somewhat translucent in age, very viscid, base bulbous; odor and taste faintly farinaceous; spores 8–10 × 3–3.5 μ, staining bluish gray with iodine in chloral hydrate; basidia four-spored; pileus trama divided into two regions by a zone of cells with dark brown contents, upper half gelatinous, lower portion filamentose; the stipe with a thick gelatinous sheath.

Gregarious under conifers, Wagner's Falls, Munising, Michigan, Sept. 7, 1933 (*33–896*) and Warrensburg, New York, Sept. 4, 1934 (*903*). The collections described above contain smaller fruiting bodies than those originally described by Karsten. A difference in size alone however is not important. The conic to campanulate pileus, the spores, and the bulbous base of the stipe, as Karsten pointed out, separate the species from *Mycena vulgaris*, its nearest relative. The spores of *M. vulgaris* usually measure 6–8 × 4–5 μ. No reddish spots were noticed in either of the writer's collections but since both were made during comparatively dry weather it does not seem advisable to place much emphasis upon their absence.

MYCENA SCABRIPES Murrill (FIG. 3: 6, 7).

Pileus 1.5–3.5 (5) cm. broad, evenly conic, convex, becoming plane with a small conic umbo, pruinose at first, soon polished, "mummy brown" to "clove brown" on the disk, "olive-brown" to "buffy brown" on the striatulate margin, hygrophanous, fading to near "drab" disk remaining darker, surface often rugulose

around the disk, margin appressed against the stipe at first; flesh thick on the disk, thin toward the margin, dark brownish gray, rather firm, odor and taste not distinctive; lamellae adnate to broadly adnexed, seceding readily and at times adhering to each other forming a collar around the stipe, broad, subdistant to distant, pallid to grayish, edge pale or grayish, pruinose under a lens; stipe 4–10 cm. × 2.5–5 mm., equal, hollow, fragile, at first densely pruinose, in age subsquamulose, glabrescent and silky

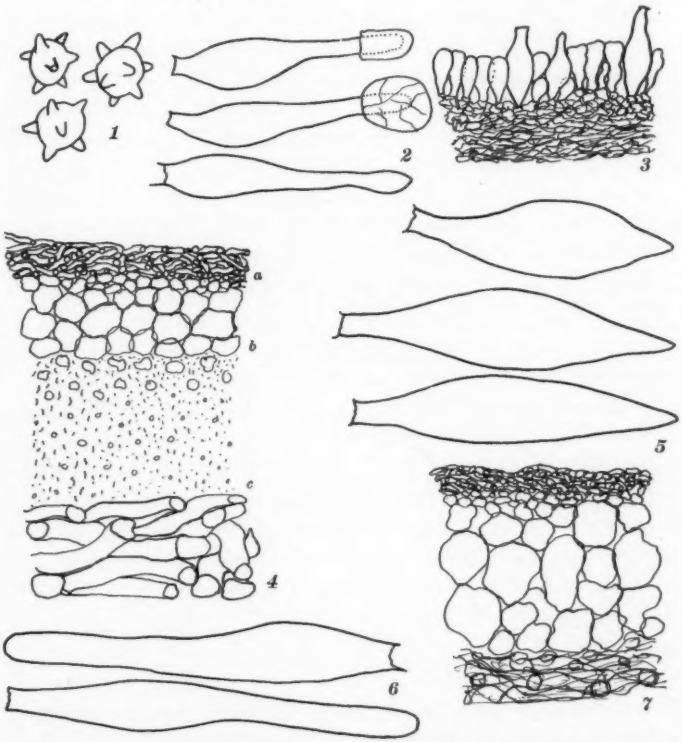

FIG. 3. 1–3, *Mycena nodulosa* Smith: 1, spores, × 1100; 2, cystidia from the sides of the gills, × 620; 3, tangential section showing the cellular structure of the surface of the pileus, × 450. 4–5, *Mycena tenax* Smith: 4, tangential section through the pileus showing *a*, the pellicle, *b*, the pseudoparenchymatous layer, *c*, the gelatinous layer above the filamentose trama, × 275; 5, cystidia from the sides of the gills, × 750. 6–7, *Mycena scabripes* Murrill: 6, cystidia from the sides of the gills, × 750; 7, tangential section of pileus showing the region of inflated cells beneath the pellicle, × 275.

striate at times, pale olivaceous brown or grayish, apex pallid; spores 7–9 (10) × 5–6 μ, broadly ellipsoid, staining faintly bluish with iodine in chloral hydrate; basidia four-spored; cystidia very abundant on the sides and edges of the gills, 60–100 × 8–14 μ, smooth, with an inflated base and a long narrow neck, apex obtuse; pileus trama with a thin pellicle over the surface from which project occasional cystidia, beneath this a region of enlarged cells, the remainder of loose floccose filamentose tissue.

Gregarious on humus in oak groves near Ann Arbor, Oct. 5 (*32–515*), Oct. 15 (*32–548*) and Oct. 20, 1932 (*32–647*). Singly to gregarious on exposed soil and along trails under redwoods, Oric, California, Dec. 3 (*3736*), Dec. 4 (*3752*) and Dec. 5, 1935 (*3785* and *3812*). The spores of the type measure 8.5–11 × 6–7 μ, and the basidia are two-spored. Cystidia are scattered on the sides and edges of the lamellae, are cylindric to subfusoid, smooth, apices obtuse, and measure 77–95 × 8–10 μ. The colors of fresh pilei are darker than those given by Murrill, but the densely pruinose to scabrous stipe, the long cystidia and broad, subdistant gills amply characterize the species. Large fruiting bodies might be mistaken for a species of *Tricholoma*, but the stipe is very fragile. Both this species and *Mycena atribrunnea* Murrill should be carefully compared with *Collybia floccipes* Fries. During the spring of 1935 *M. atribrunnea* was collected very abundantly in the vicinity of Ann Arbor. The stem is at first scurfy from a dense coating of fine particles the tips of which are tinged gray or brownish. This coating is easily removed and then the stem is pure white. Kauffman's (**8**) specimens of *Collybia floccipes* are similar to those Murrill described as *Mycena atribrunnea*. The stipe of *Mycena scabripes* also indicates a close relationship to *C. floccipes*, and Cook's (**3**) illustration which Rea (**14**) cites could easily be either a large form of *M. atribrunnea* or a small *M. scabripes*. Because the pileus structure in both of Murrill's species resembles more closely that of *Mycena* than that of *Collybia*, it seems best to retain them in the former genus.

MYCENA TENELLA (Fries ex Schum.) Quél.

Pileus 3–10 mm. broad, obtusely conic, remaining so in age, glabrous, moist, striate at first, somewhat sulcate in age, "light pinkish cinnamon" to "vinaceous-buff" fading to nearly white with a faint rosy tint or the disk finally creamy yellowish; flesh

thin but cartilaginous and firm; lamellae narrow, close to subdistant, adnate, white or tinged with rose, edge at very first tinged with rose but soon white or concolorous with the sides; stipe 6–10 cm. × 1 mm. glabrous, dark drab gray with a paler apex, rather firm and elastic; spores 8–10 × 5–6 μ, smooth, hyaline, staining faintly bluish gray with iodine in chloral hydrate; cystidia abundant on edge and rare or scattered on the sides of the lamellae, the apices echinulate; basidia four-spored.

Cespitose to densely gregarious on dead clumps of fern roots in low land, Joyce, Washington, Oct. 3, 1935 (*2834*). This species is close to *Mycena mirata* Peck from which it differs in its lighter more rosy color and cespitose habit. The stems in the above collection were longer than usual.

MYCENA TRACHYSPORA Rea (FIG. 1: 6).

Pileus (6) 10–20 (30) mm. broad, conic, campanulate, becoming expanded and umbonate, at first densely hoary, polished at maturity, surface dry, disk at first dark "fuscous" or "bone brown," paler and grayish toward the margin, in age paler over all and often with a tinge of sordid ochre, somewhat striate at first; flesh firm and cartilaginous, odor and taste not distinctive; lamellae moderately close, narrow to moderately broad, oval in outline, narrowly adnate, pale grayish with a pallid margin, densely pruinose under a lens; stipe 4–12 cm. × 1–2 mm., equal, tough and cartilaginous, pallid gray above, darker and more brownish below, evenly covered by a dense layer of cystidia, appearing pubescent under a lens; spores 4–5.5(6.5) μ, pale yellowish with iodine in chloral hydrate; basidia four-spored; cystidia abundant on sides and edges of the gills, 40–75 × 8–12 μ, fusoid-ventricose or with a long projecting shaft with an obtuse apex, smooth or rarely with the lower portion of the shaft incrusted; pileus trama homogeneous, covered by a thin pellicle from which occasional cystidia arise.

This species approaches *Mycena Cooliana* Oort very closely, but the gills were neither thickish nor subdistant, and incrusted cystidia were rarely found. When present, the incrustation is not over the apex but at the base of the neck. Fruiting bodies with stems 12 cm. long and pilei 3 cm. broad resemble *M. nodulosa* in general appearance but are easily distinguished by the lack of a long pseudorhiza and the thin pellicle of the pileus. Mr. H. E. Parks and the writer collected this species fairly abundantly under

pure stands of redwood in northern California, Dec. 2–3, 1935 (*3718*) and (*3731*).

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CYTOLOGY OF SPORE GERMINATION IN THE BISPORED FORM OF PSALLIOTA CAMPESTRIS

J. E. Sass

(WITH 1 FIGURE)

The nuclear phenomena in the mycelium and hymenium of the bispored form of *Psalliota campestris* have been studied by several investigators, who are in substantial agreement with respect to most of the nuclear cycle. One point of controversy concerns the number of nuclei which enter each spore. Buhr (**1**) states that only one of the four nuclei in the basidium enters each of the two spores, whereas Miss Colson (**2**) and the present writer (**3**) agree that two nuclei enter each spore.

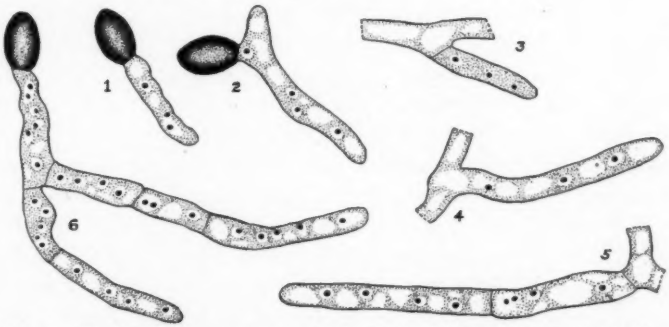

FIG. 1. Nuclear features of germ tubes of the bispored forms of *Psalliota campestris*.

A commercial culture which is grown here was found to have the same nuclear features as the material previously studied by the writer, further supporting Miss Colson's account. Spores of the present strain germinated readily, making possible a study of this little-understood phase of the nuclear cycle.

As illustrated in figure 1, the young, unseptate germ tube is multinucleate. Septation occurs with the growth and branching of the mycelium, the cells of which are multinucleate. This condition is a constant feature of the mycelium, whether derived

from single spores, mass smears of spores, or tissue cultures of the fruit body.

These nuclear conditions eliminate the use of nuclear criteria of heterothallism or homothallism and makes necessary the continuation of culture experiments, using giant cultures, rather than the flats of compost used heretofore in such tests.

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A NEW SPECIES OF CHONDROPODIUM ON PSEUDOTSUGA TAXIFOLIA

W. LAWRENCE WHITE [1]

(WITH 7 FIGURES)

The sphaeropsidaceous fungus, here discussed, was first encountered by Doctor J. S. Boyce of Yale University near Bear Springs, Clackamas County, Oregon, August 23, 1930. Two additional collections were made by J. R. Hansbrough near Revelstoke, British Columbia and Madras, Oregon in August of 1930 and 1931 respectively. The organism was found in small sunken lesions in the outer cortex of smooth-barked trees of *Pseudotsuga taxifolia*. It is stated by the collectors to be common but not serious from the disease standpoint.

Impressed by the superficial resemblance of the fruit-bodies of the fungus to those of *Caliciopsis*, Doctor Boyce sent material of the three collections to Professor Fitzpatrick. Careful search of the literature having failed to reveal any record of the occurrence of such a form on *Pseudotsuga* or any closely related host, the writer, at Professor Fitzpatrick's suggestion, undertook the study which has resulted in the preparation of this paper.

The lesions occupied by the fungus are small, superficial, slightly sunken, and often somewhat orbicular in shape, being then slightly greater in lateral than in vertical diameter (FIG. 3). They measure 1–2 × 1–1.5 cm. The outer cortex has a tendency to crack along the margin of the cankered area and to pull away from the adjacent healthy tissue, leaving the canker sharply defined. From two to a dozen erumpent (FIG. 3) pycnidia occur, scattered over the central area of each canker. The pycnidium is an erect columnar body, chiefly cylindrical, but sometimes spreading at the base, and typically compressed apically when dry (FIG. 2). It measures 1–1.5 mm. in height and 125–200 μ in thickness. The spreading base, more or less covered by the

[1] The writer wishes to acknowledge his indebtedness to Doctor H. M. Fitzpatrick for valuable suggestions and for a critical reading of this paper.

thin outer cortical layer of the host, may attain a diameter of 500 μ. Though the pycnidia usually stand singly, two or three may be found clustered together, their bases sometimes united in a common basal stroma. Externally the pycnidium is black

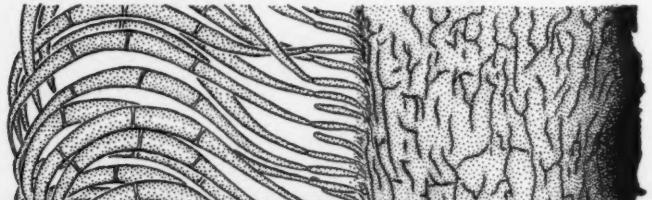

FIG. 1. Lateral wall of pycnidial cavity of *Chondropodium Pseudotsugae* bearing conidiophores and conidia. (Drawn to a magnification of 720 with aid of camera lucida and not reduced in reproduction.)

and minutely scabrous. The pycnidial cavity occupies the apical region of the column (FIG. 5, 6, 7). In wet weather it opens by a broad circular ostiolum freeing its crescent-shaped, 4-celled conidia. When dry it collapses completely, the compressed apex of the column then having the aspect of a coarsely toothed wedge (FIG. 2). The column beneath the locule is composed of a compact, subgelatinous to cartilaginous tissue, formed of closely interwoven hyphae which are chiefly subhyaline but at the periphery are darkened to provide a thin black rind (FIG. 6).

Since the genus *Chondropodium* is not well known, and because of the confused ideas of the limits of related genera, a brief discussion of our reasons for placing the species in this genus will be given.

The organism is excluded from *Sphaerographium* Saccardo because of its septate spores. It is excluded from *Pseudographium* Jaczewski because the description of the latter genus as amended by von Höhnel (1, no. 921, pp. 67–69) with *P. Persicae* as the type, calls for pycnidia composed of brown

parallel hyphae, and a columnar stalk arising from hyphae superficial on the substratum. Examination of *P. Persicae* shows it to be strikingly different in gross aspect from the fungus with which we are dealing here.

The genus *Cornicullariella* Karsten (**3**: 57), based on *C. Abietis* Karst., was characterized by him as having erect, superficial, caespitose, or rarely single pycnidia, and septate, hyaline or yellowish pycnospores. In 1890, apparently without reason and without giving any explanation he (**4**: 19) changed the name of the genus to *Cornularia*. By 1916 eleven additional species had been placed in the genus. At that time von Höhnel (**2**, no. 958, 19–21) showed that all except three of these belong to other genera, these three—*C. spina* (Berk. & Rav.) Sacc. & Sydow, *C. Viburni* Sacc. and *C. Urceolus* v. Höhn.—being regarded by him as closely related species which might well be retained and treated as a genus. Meanwhile, *C. Abietis*, on which the genus *Cornicullariella* had been based, apparently had not been collected again and was known only from the inadequate original description. This led von Höhnel (**2**, no. 956, p. 42, no. 958, p. 45) to suggest that Karsten's description might have been based on a specimen of *Gelatinosporium Pinastri* (Moug.) v. Höhn. Knowing *C. Abietis* only from Karsten's description he made it synonymous with *Gelatinosporium Pinastri*, thus making *Cornularia* a synonym of *Gelatinosporium* Peck, and erected, for the three species named above, a new genus, which he named *Chondropodium*, it being his opinion that *Cornularia* should remain monotypic at least until the type species should become better known. Finally he placed in *Chondropodium* the species *Sphaerographium hystricinum* (Ellis) Sacc., stating on meagre evidence that in its perfect stage it also belongs to the genus *Godronia*.

A close relationship of *Chondropodium* to *Gelatinosporium* is indicated by von Höhnel, and perhaps not essentially different is the genus *Micropera*.

Though the original description of *Cornularia* states that the pycnidia are superficial, the species placed in *Chondropodium* as well as *Gelatinosporium Pinastri* have actually erumpent pycnidia. It seems likely, therefore, that the terms "erumpent" and "superficial" were used somewhat vaguely by these authors.

Von Höhnel did not present a formal diagnosis of his new genus, *Chondropodium*. He wrote as follows concerning the species on which it was established:

"Diese Pilze haben ein eingewachsenes schwarzes Hypostroma, auf dem, meist büschelig verwachsen, mehrere aufrechte, meist sehr unregelmässig gestaltete, aussen schwarze, innen blasse, gelatinös-knorpelige Stromata sich erheben, die aus plectenchmatisch verflochtenen, knorpelig-dickwandigen Hyphen bestehen, oben meist konisch verschmälert sind und daselbt einen aufrecht-elliptischen oder zylindrischen Lokulus zeigen, in dem sich auf einfachen Trägern spindelig-zylindrische, lange, hyaline, einzellige oder undeutlich zweibis mehr-zellige Conidien finden. Lokulus schliesslich sich oben klein, rundlich öffnend."

This description applies extremely well to our fungus on *Pseudotsuga taxifolia*. In the erumpent character of the pycnidium, the gelatinous-cartilaginous nature of its tissue, the form and method of dehiscence of its locule, and in the shape and septation of its conidia there is complete agreement. Whether in its perfect stage it is a *Godronia* is not known.

In erecting the genus *Chondropodium* it is clear that von Höhnel has attempted to bring together related species. Students who regard the classification of the Fungi Imperfecti as merely a cataloging system based on artificial characters may raise objection to the recognition of this genus on the ground that it represents unnecessary splitting of the older more inclusive genus *Cornularia*. While it will be admitted that classification in the group as a whole must of necessity rest on artificial bases, there seems to be no sound objection to placing subdivisions of the group on a natural phylogenetic basis where possible. For this reason we prefer to place the organism under discussion in *Chondropodium* rather than in the larger and admittedly artificial genus *Cornularia*.

Chondropodium Pseudotsugae sp. nov.

Pycnidiis plerumque singulis, rarius vel binis vel quaternis, erumpentibus, stipatis, columnaribus, erectis, 1–1.5 mm. altis, in superiori parte cylindraceis 125–200 μ diam.; basi interdum ad 300–500 μ incrassante partimque summo cortice immersa; extrinsecus atris, minuteque scabriosis, duris ac fragilibus si sicca; ostiolo largo, circulari, compresso et occluso si siccum; loculis sporiferis, per totam interiorem faciem conidiophoris vestilis, elongatis, 1/4–1/3 superioris

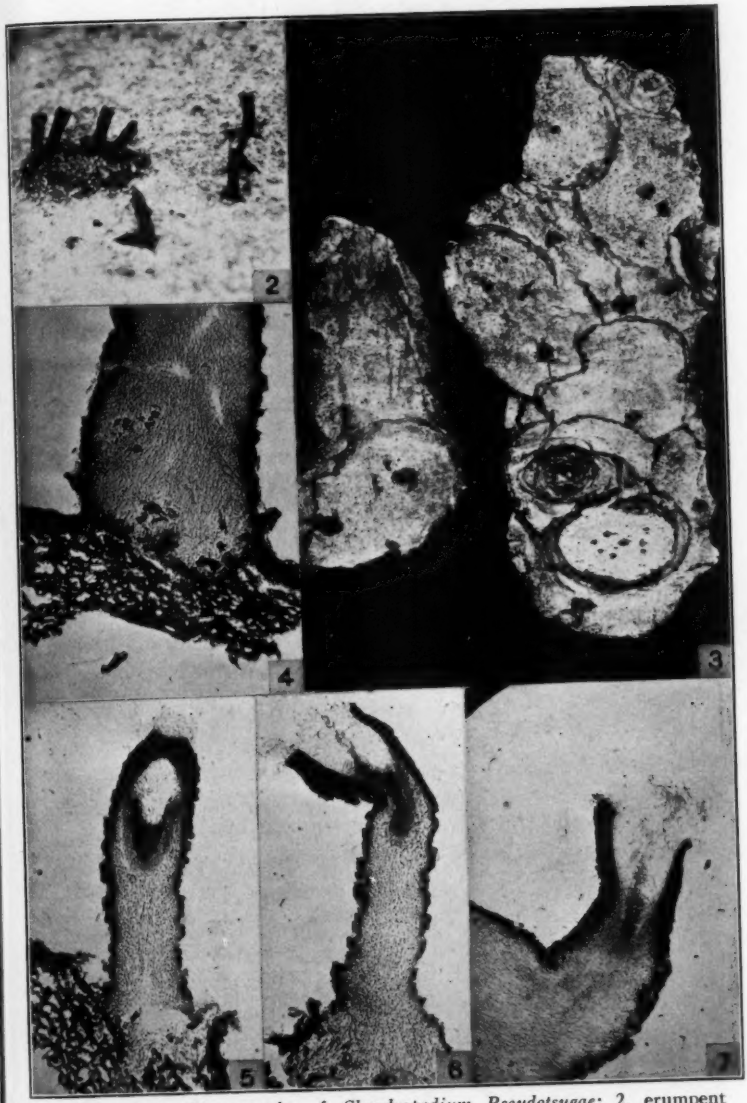

FIG. 2–7. Photographs of *Chondropodium Pseudotsugae:* 2, erumpent pycnidia in canker, × 3.8; 3, characteristically sharply delimited cankers on *Pseudotsuga taxifolia*, × 1.4; 4, longitudinal section through erumpent basal portion of pycnidium, × 28; 5, longitudinal section through pycnidium, not median at apex but indicating position and width of ostiolum through which extruding spores are shown, × 28; 6, 7, pycnidium in longitudinal section, the locule apparently widely dehiscent due to spreading of walls following sectioning, × 28.

columnae partem obtinentibus; basi sterili, ex hyphis facta septatis, dense intectis, ramosis, quae agglutinatae texturam reddunt subgelatinosam oel etiam cartilaginosam, fuscis circum fructus superficiem, tenuem et atram crustulam efficientibus; conidiophoris simplicibus, aseptatis, 12–16 × 2–2.5 μ; conidiis hyalinis, 35–60 × 3.5–4.5 μ, si libera, lunatis vel falcatis si conidiophoris adhaerentia, a basi plus minus rectis, 4-septatis, cellulis plures olei guttas continentibus.

Hab. in fossulis (1–2 × 1–1.5 cm. diam.) leviter depressis in viridi cortice *Pseudotsugae taxifoliae* (Lam.) Br., British Columbia et Oregon in America boreali.

Pycnidia occurring singly or more rarely in groups of two to four, erumpent, stalked, columnar, erect, 1–1.5 mm. high, cylindric above, 125–200 μ diam., sometimes more or less spreading at the base to 300–500 μ, the enlarged portion partly buried in the outer layer of the cortex, externally black, minutely scabrous, drying hard and brittle; ostiolum broadly circular, compressed and closed when dried; sporiferous locule lined with conidiophores, elongate, occupying the upper one-fourth to one-third of the column; the sterile basal portion composed of densely interwoven, branched, septate hyphae which have a tendency to become agglutinated and give the tissue a subgelatinous to cartilaginous character, darkened around the outer surface of the fruit body to form a thin black layer; conidiophores simple, one-celled, 12–16 × 2–2.5 μ; conidia hyaline 35–60 × 3.5–4.5 μ, when lying free crescent-shaped or sickle-shaped, when attached to the conidiophores more or less straight at the basal end, 4-celled, each cell containing several oil drops.

Occupying small superficial sunken lesions, 1–2 × 1–1.5 cm. diam. in the cortex of young, living, smooth-barked trees of *Pseudotsuga taxifolia* (Lam.) Br. British Columbia and Oregon.

Type collected near Bear Springs, Clackamas County, Oregon, Aug. 23, 1930, by J. S. Boyce (Cornell University, Department of Plant Pathology Herbarium No. *24008*).

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ZONATION IN ALLOMYCES ARBUSCULA[1]

WINSLOW R. HATCH

(WITH 5 FIGURES)

Allomyces arbuscula grown on agar and exposed to those conditions of light and temperature ordinarily obtaining in the laboratory shows a characteristic banding of the myeclium (FIG. 1). Zones of compact hyphal growth and heavy gametangial or sporangial production alternate with zones of diffuse hyphal growth in which the gametangia or sporangia are few and scattered.

In the formation of the heavy bands the advancing hyphae first divide dichotomously. These bifurcated hyphae then resume their forward growth but in this growth the arms of the dichotomies tend to parallel each other closely, failing in any notable divergence. This growth, however, is soon interrupted by the formation of numerous reproductive bodies which ultimately accumulate in such numbers as to form a ridge on the surface of the agar. Since the peak of this intense reproductive activity is achieved quickly and falls off slowly the ridge rises sharply in front, falls off gradually behind. At the point where the ridge flattens out the zone of diffuse growth begins. By marking the extent of mycelial growth every four hours it was discovered that the dense, heavily reproductive growth began between 4–8 in the morning, reached its peak about noon, and falling off during the afternoon and evening, ran out between 10–1 at night. The diffuse growth was thus limited to the midnight and early morning hours.

In searching for the cause of this zonation diurnal changes in light and temperature both offered plausible explanations. Light, however, was quickly ruled out by growing the fungus in absolute darkness. When growth rings continued to form it seemed certain that zonation could not be due to any day and night change in illumination. In this experiment Petri dish

[1] Botanical contribution from the Johns Hopkins University, No. 131.

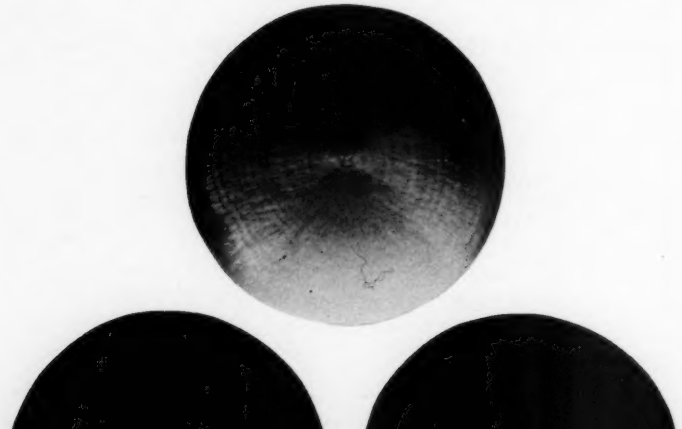

FIG. 1–5.

cultures of both sexual and asexual mycelia were placed in a specially designed dark room and left undisturbed for 7 days. Temperature was not controlled. Other cultures comparable in every respect were exposed to diurnal illumination in the greenhouse where the temperature was likewise variable. Growth rings formed in both instances.

In studying the relation of temperature to zonation cultures were placed in a constant temperature apparatus where the temperature could be held to a fluctuation of ½° C. The constant temperature apparatus used in this experiment had eight compartments each set at a different temperature. The temperatures used were 7° C., 13° C., 17.5° C., 22° C., 26° C., 30° C., 34° C. and 37° C. Into each of these eight compartments two sexual and two asexual cultures were placed. The apparatus was then closed and the cultures left undisturbed for 7 days. Other cultures, comparable in every respect, were left on top of the constant temperature apparatus where they were exposed to diurnal changes in temperature as well as light. When the apparatus was subsequently opened no semblance of rings could be seen in any culture grown therein (FIG. 2, 3). The controls on the other hand were characteristically banded. This would seem to prove conclusively that diurnal changes in temperature are responsible for zonation in *Allomyces arbuscula*.

The question next arises as to how great the change in temperature need be. To get at this a sexual and an asexual culture from the 37°, 34°, 30°, and 26° compartments were placed in the 22° compartment. This represented a change of 15°, 12°, 8° and 4° respectively. A sexual and an asexual culture from the 7°, 13° and 17.5° compartments were likewise placed in the 22° compartment. This represented a change of 15°, 9°, and 4.5° respectively. After this transfer the constant temperature apparatus was closed and left undisturbed for three days. When opened it was discovered that every culture that had been moved into the 22° compartment formed a single sharp ring (FIG. 5). The 22° cultures and those left undisturbed in their original compartments still failed to develop rings. A change in temperature of as little as 4° C. is then enough to induce ring formation. Furthermore, this change in temperature can be in either direction, up or down.

While the above experiment demonstrated a surprising temperature sensitivity in the mycelium it remained for a subsequent experiment to show just how sensitive the mycelium actually is to temperature changes. Cultures placed in a dark room where there was a daily fluctuation of only 1½° C. (18¾°–20¼°) continued to form rings; these rings, however, were less distinct than any seen heretofore (FIG. 4).

With the knowledge that only a degree or a degree and one-half change in temperature is necessary to cause ring formation the question next arises as to how long these temperature changes need to be. To test this another set of cultures were run in the constant temperature apparatus and again a sexual and an asexual culture were changed from each of the different temperature levels to the 22° compartment, but this time these cultures were only left at the 22° level for one hour before returning them to their original compartments. Controls were kept by leaving one sexual and one asexual culture in each compartment. A sharp ring formed in the transfers, none in the controls. Since it was already known that momentary changes up to 5–10 minutes did not cause ring formation this experiment proved that the time requirement in temperature changes lies somewhere between 5–10 minutes and 1 hour. By marking the extent of mycelial growth at the time of transfer, it was definitely ascertained that the heavy growth ring was set off soon after the transfer was made. This analysis, however, was not carried farther.

To the last three experiments the objection might be raised that in the transfer of cultures to one temperature from several others the momentary exposure to light might be significant. Accordingly the last experiment was repeated only the controls in the bottom of the several chambers were given the same exposure to light as the transferred cultures. Again no rings formed in the controls so it would seem that light in short sharp exposures is no more effective in causing zonation than longer, diurnal exposures.

The cause of zonation in fungi has been investigated by a great many workers in many different species and while zonation has been variously attributed to light, to media, or to more or

less inexplicable biological periodicities they are agreed, with but one exception, that temperature does not effect zonation. The exception has been described by Bisby [1] for *Fusarium discolor sulphureum* where temperature as well as light may cause zonation. In *Allomyces arbuscula* we have another exception—a very striking exception—for in this species temperature alone effects zonation, light causing no demonstrable effect whatever. Now it may very well be that temperature is an inconsequential factor in other fungi but the fact that in *Allomyces* temperature had to be held to less than a 1½° fluctuation before an effect could be demonstrated suggests that like treatment in other species may result in like results. In any event, any investigation of zonation must hereafter seem inconclusive unless temperature is very carefully controlled.

SUMMARY

1. Zonation in *Allomyces arbuscula* represents a periodic massing of hyphae and reproductive structures.

2. Under the conditions ordinarily obtaining in the laboratory, there is a diurnal rhythm in zonation, a heavy ring being laid down between 6^{+-} A.M. and 12^{+-} P.M., a diffuse one between 12^{+-} P.M. and 6^{+-} A.M.

3. Diurnal illumination shows no apparent causal relationship with ring growth.

4. Growth rings are caused by diurnal fluctuations in temperature.

5. A fluctuation between ½° and 1½° C. is enough to cause growth ring formation.

6. The knowledge that fungus mycelia may be extremely sensitive to temperature changes suggests that temperature may exert a more profound influence on zonation than has been assumed.

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[1] Bisby, G. R. Zonation in cultures of *Fusarium discolor sulphureum*. Mycologia **17**: 89–97. 1925.

EXPLANATION OF FIGURES

Fig. 1. A sexual mycelium showing the characteristic type of zonation found in cultures exposed to diurnal changes in light and temperature. Figs. 2 and 3. A sexual and an asexual mycelium respectively showing the complete lack of zonation characteristic of cultures grown at constant temperatures; *i.e.*, at temperatures held to a ½° fluctuation. These particular cultures were taken from the 34° C. compartment of the constant temperature apparatus. Fig. 4. An asexual mycelium showing the type of zonation induced by a daily fluctuation in temperature of 1½° C. Fig. 5. An asexual mycelium showing the single growth ring characteristic of those cultures in the constant temperature apparatus that experienced a single change in temperature during the course of their development. The change in this instance was only 4°, from 26° C. to 22° C.

THE PERSISTENCE OF HYPHOLOMA INCERTUM ABOUT TREE STUMPS[1]

F. C. Stewart

Like many other agarics which grow on the ground about stumps or over buried wood *Hypholoma incertum* frequently appears year after year in approximately the same place. The writer has attempted to determine how long this fungus may continue to appear about a particular stump and the number of crops per season which it may produce. The data presented have been gathered from observations on four stumps in lawns in the city of Geneva, N. Y. The soil around all four of the stumps was a rather heavy and moderately fertile clay loam. The surface drainage was good. All were exposed to the sun.

STUMP NO. 1

Stump No. 1 belonged to a shagbark hickory tree (*Carya ovata* K. Koch). The top of the tree, having died, was removed in 1915 leaving a stub 11 feet tall and 16 inches in diameter with three living branches at the top. In 1925, while the branches were still partly alive, the stub was sawed off even with the surface of the soil.

On August 6, 1918, a colony of *H. incertum* appeared close to the stump. This is believed to be the first occurrence of the fungus anywhere about the stump. Although the spot had been under observation by the writer since 1909 when the lawn was established, *H. incertum* had never been seen there, not even in the wet season of 1917 when several large gatherings of it were made elsewhere in Geneva.

Each year since 1918 it has been the writer's aim to record the size, location, and date of appearance of each colony appearing about the stump. Undoubtedly, the record of observations, shown in Table 1, is incomplete, particularly for the years 1921,

[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 123, February 15, 1936.

TABLE 1

THE OCCURRENCE OF *Hypholoma incertum* ABOUT A HICKORY STUMP

Date	Number of sporophores	No. of crop	Location of colony with respect to the stump
1915	None		
1916	None		
1917	None		
6 Au. 1918	Several	1st	Close on the northeast
12 Je. 1919	Many	1st	Close on the east
14 Je. 1919	Many	1st	Close on the north
2 Jl. 1919	Many	2nd	Close on the north and east
23 Au. 1919	Many	3rd	Close on the north and east
22 Je. 1920*	A few	1st	Close on the east
4 Jl. 1920*	A few	2nd	Close on the east
23 Jl. 1920	Many	3rd	Close on the east
13 S. 1920	Many	4th	Not recorded
1921	None recorded	—	No record
7 Je. 1922	Many	1st	From stump southward 10 feet
14 Je. 1922	Thick over area 4 ft. in diam.	2nd	Close on the south
16 Je. 1922	About 25	2nd	Close on the northeast
16 Je. 1922	A few	2nd	15 ft. northeast
16 Je. 1922	Many	2nd	South and southeast over a distance of 25 ft.
22 Je. 1922	Many	3rd	From stump southward 10 feet
2 Jl. 1922	Many	4th	On the south
24 Jl. 1922	About 25	5th	On the south
9 Je. 1923	Many	1st	About 6 feet southwest
11 Je. 1923	Thick over area 6 ×10 ft. in diam.	1st	On the south and southwest
12 Je. 1923	Many	1st	On the west
2 Jl. 1923	Thick over area 6 ft. in diam.	2nd	On the south
9 Jl. 1923	Many	3rd	On the south
28 S. 1923	12	4th	On the south
26 Je. 1924	Many	1st	Extending southwesterly 23 feet
2 Jl. 1925	A few	1st	On the south
22 Jl. 1925	A few	2nd	On the southwest
27 Jl. 1925	Many	2nd	On the southwest
19 S. 1925	Many	3rd	Close on the southwest
2 Au. 1926	A few	1st	Close on the southwest
11 Au. 1926	Many	2nd	Close on the southwest
11 Au. 1926	A few	2nd	14 feet southwest
13 S. 1926	Several	3rd	Close to the stump
13 S. 1926	10	3rd	20 feet southwest

* Exact date uncertain.

TABLE 1—*Continued*

Date	Number of sporophores	No. of crop	Location of colony with respect to the stump
1927	None recorded	—	No record
20 Je. 1928	7	1st	Close to the stump
27 Je. 1928	A few	2nd	Not recorded
1929	None recorded	—	No record
20 Je. 1930	Several	1st	Close to the stump
5 Je. 1931	A few	1st	10 feet northwest
8 Jl. 1932	50 or 60	1st	10 feet northwest
1933	None		
1934	None		
1935	None		

1924, 1927, 1930, and 1933, when the writer was away from Geneva most of the time during July and August. However, it is certain that the fungus persisted at least 14 years (1918 to 1932) and produced from one to five crops each season except, possibly, in 1921, 1927, and 1929. Large colonies were seen in 1919, 1920, 1922, 1923, 1924, 1925, and 1926. There were two small colonies in 1928 and a single small one in each of the four years 1918, 1930, 1931, and 1932. None have been seen since 1932. On June 25, 1935, when the fungus was appearing elsewhere in the vicinity none occurred about the hickory stump. It seems to have run its course there.

Clearly, the time of appearance of a crop of the fungus was determined primarily by the rainfall. The large crops closely followed rain periods of three to five days with a total rainfall of about 1.5 inches or more. They occurred at various times between June 7 and September 19. Sometimes, when a crop consisted of colonies at different points the several colonies did not all appear on the same day as, for example, in the second crop of 1922 and the first crop of 1923 (Table 1). Sometimes a crop occupied almost exactly the same area or areas as the preceding one, but more often the later crop had a somewhat different location.

Prior to 1922 all of the colonies were located close about the stump. From 1922 on some were close to the stump while others were found at distances of several feet from the stump. In the second crop of 1922 sporophores of the fungus were thinly scattered along a strip 1.5 to 3 feet wide extending from the stump toward the southeast to a distance of 25 feet. At other times similar long narrow colonies of scattered plants extended toward the south and southwest, indicating the course of shallow roots. However, none of the roots showed at the surface of the soil.

The abortive sporophores of some polypore, probably *Fomes applanatus* (Pers.) Wallr., on the stump from 1926 to 1928, were the only indication of the presence of any wood-inhabiting fungus which might have been a competitor of the *Hypholoma*.

STUMP NO. 2

Stump No. 2 belonged to a sugar maple tree (*Acer saccharum* Marsh.). It stood in a 4-foot-wide strip of lawn between a concrete sidewalk and the street curb. The tree died from an undetermined cause early in the spring of 1923 after putting out a few leaves. It was felled the following summer. The stump was 15 inches in diameter. The first appearance of *Hypholoma incertum* here was on June 12, 1923, when a small colony was found on the east side of the stump. On June 26 of the following year a single colony containing several plants appeared in the same place. In 1925 the fungus was seen twice—on July 17 north of the stump and about July 1 when neither the date nor the location was recorded. Finally, a colony containing several sporophores was recorded on July 22, 1926, and none since.

Here, the fungus was in severe competition with *Coprinus micaceus* Fries, which first appeared in May, 1924, and was plentiful all around the stump each season during the next nine years. On June 22, 1926, sporophores of the two species grew in close association.

STUMP NO. 3

Stump No. 3 belonged to an elm tree (*Ulmus americana* L.). It was under observation from the time the tree was felled in the autumn of 1917 until the autumn of 1933 when it had become a

mere shell filled with powdered rotten wood. This stump was 4 feet in diameter and 12 to 18 inches tall. *Hypholoma incertum* began to appear in 1922 producing seven separate crops that year, nine crops in 1923, one in 1924, two in 1925, and one in 1928. Some colonies were close to the stump while others were at various distances up to 20 feet from it. A tendency was shown to follow the course of hidden roots as in the case of the hickory stump. Heavy watering of the stump and surrounding soil during spells of dry weather is partly responsible for the large number of crops produced in 1923. During the same period large colonies of *Coprinus micaceus* Fries, and *Psathyrella disseminata* Fries occupied the same areas as the *Hypholoma* and must have competed with it for nourishment. Between May 15 and December 3, 1923, 38.25 pounds of *Coprinus micaceus* caps were gathered about this stump.[2]

STUMP NO. 4

The fourth stump belonged to a large apple tree (*Malus domestica* Borkh.). It had been dug out and the hole filled in 1916 or earlier. Nothing is known about the mycology of the spot prior to June 14, 1917, when large numbers of *Hypholoma incertum* sporophores were discovered growing there in an ellipse of 6 × 4 feet. A second large crop was found covering the same area on June 25, 1917. The third crop, a basketful of fine specimens, was gathered from the same area on July 17, 1917. A few sporophores which appeared on September 7 represent the fourth and last crop of 1917.

In 1918, also, there were four crops, namely, a dozen large sporophores on May 21, a large number on May 28, a basketful on August 6, and a large crop on August 14.

In 1919 two crops were recorded—several sporophores on May 30 and a large crop on August 23.

In 1920 a basketful was recorded on June 24, and in 1922 "some" on June 11.

No competing fungus was seen here during the six seasons covered by the observations.

[2] Stewart, F. C. The mica ink-cap or glistening *Coprinus*. New York State Agr. Exp. Sta. Bull. No. 535: 14. 1926.

DISCUSSION

From these observations it appears that the fungus may persist from 4 to 14 years and the number of crops per year may vary from one to nine. The amount and distribution of the rainfall largely determine the number of crops per year; but the cause of the wide variation in the length of the period of persistence is not so readily explained. In the first place it is uncertain to what extent new colonies come from mycelium living from year to year in the roots of the stump and to what extent they may result from annual reinfection by means of spores. The tendency of the fungus to appear at approximately the same point in successive years suggests a perennial mycelium. On the other hand, the frequency with which the fungus occurs indicates that the conditions necessary for infection by spores are not difficult to satisfy. Hence, it seems probable that both methods of sporophore production may be in operation.

In the case of the hickory stump, where the fungus persisted for 14 years, the period of persistence was prolonged, probably, by the gradual dying of the tree. Some roots must have died several years before all were dead, thereby furnishing a succession of roots in suitable condition to become a substratum of the fungus. Although *Hypholoma incertum* sometimes appears about a tree before all of the parts above ground are dead, it has not been proved, so far as the writer knows, that the fungus is capable of attacking living roots.

It is possible that the competition and antagonism of other wood-inhabiting fungi were important factors in determining the length of the period of persistence. So far as above-ground indications go there was less interference by other fungi around the hickory stump than around either the maple stump or the elm stump, but there is no means of knowing to what extent the unseen roots were invaded by the mycelia of other fungi which did not appear above ground.

Other factors involved are the differences in the sizes of the stumps and in the species of trees to which they belong.

ASCOCALYX ABIETIS AND BOTHRODISCUS PINICOLA [1]

J. WALTON GROVES

(WITH 6 FIGURES)

During the summer of 1934 a discomycete was collected on *Abies balsamea* in the Temagami Forest Reserve, Northern Ontario, which has been identified as *Ascocalyx Abietis* Naumov. It was found associated with fruiting bodies of *Bothrodiscus pinicola* Shear, and subsequent cultural studies have shown this to be the imperfect stage. The study of this association was undertaken in connection with a more general study of conidial relations in the Dermateaceae. Since the connection of the two stages and the relationships of *Ascocalyx* are of some special interest, it seems desirable to present these results at this time.

In the Temagami region *Bothrodiscus pinicola* occurs commonly on lower dead branches, or on branches of fallen trees of *Abies balsamea*, and has not been observed on any other host. The fructifications are especially noteworthy because of the unusual pezizoid form of the stroma. They are black, or dark greenish when moist, and are quite conspicuous. The spores are produced in ovoid locules in the disc of the stroma, from which they emerge in small glomerules, forming whitish masses on the disc.

The perfect stage is found closely associated with the imperfect, but is less conspicuous and is usually not abundant. The apothecia are black with a lighter colored margin, and in the dry condition are more or less infolded and inconspicuous, but expand

[1] Contribution from the Department of Botany, University of Toronto. The writer wishes to express his appreciation and gratitude to Professor H. S. Jackson, under whose direction the work was carried on, for his helpful suggestions and criticism; to Dr. C. L. Shear for his generous co-operation in re-examining the type of *Bothrodiscus pinicola;* to Mr. E. W. Mason for examining the type of *Cenangium pithyum* Berk. & Curt., and for permission to quote from his notes; to Dr. M. W. Bannan for identifying the wood in the type collection of *Bothrodiscus pinicola*, and in the specimen of *Fusisporium Berenice* in N. Am. Fung. *376a;* and to Dr. D. H. Hamly for the photograph reproduced in figure 2.

when moistened. They commonly occur in small clusters, seated on a rounded, black, rather horny stroma. When fully mature this stroma is rather loosely attached to the substrate, readily

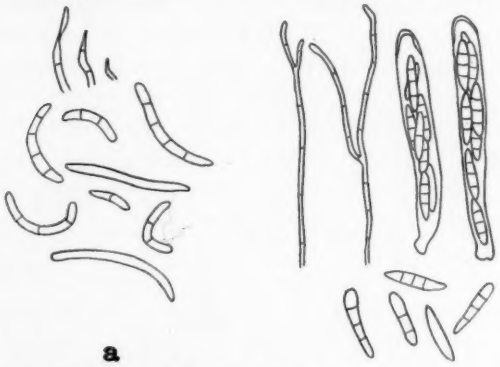

FIG. 1. a, conidiophores and conidia; b, asci, ascospores, and paraphyses. Drawn with the aid of a camera lucida. × 400.

becoming detached, and consequently the mature apothecia are easily lost in herbarium specimens unless care is exercised in handling them.

HISTORICAL

The conidial stage has been known for some time. The earliest record which has been noted is that of Berkeley (**1875a**), who described it as *Fusisporium Berenice* Berk. & Curt., having misinterpreted the structure, considering it to be an imperfect fungus parasitic on a decayed *Peziza*. He described the spores and noted that they were found in small balls, but failed to realize that the pezizoid fruiting body was itself the conidial fructification. The type was collected at Boston, Mass. Two collections were distributed under this name in Ellis' North American Fungi, *376a* and *376b*. The former was collected at Newton, Mass., and the latter at West Chester, Pa., and in each case the host is *Abies*.

The Massachusetts collection (*376a*) was made by Dr. Farlow and presumably identified by him. On the label it is suggested that the fungus might be the pycnidial form of some *Cenangium*, possibly *C. pithyum*, which was also described by Berkeley (**1875b**). In order to determine if *Ascocalyx Abietis* were

identical with *Cenangium pithyum* Berk. & Curt., Mr. E. W. Mason of the Kew Herbarium kindly examined the type of *Cenangium pithyum* and compared it with specimens of *Ascocalyx Abietis* and *Bothrodiscus pinicola* from the herbarium of the University of Toronto. He found that the type of *Cenangium pithyum* Berk. & Curt. consisted of five fruiting bodies which were identical, not with *Ascocalyx*, but with the conidial stage, *Bothrodiscus*. The following quotation is from a report by Mr. Mason dated January 7, 1936:

"*Cenangium pityum* Berk. & Curt. is the same fungus as Toronto 8287 labelled *Bothrodiscus pinicola* Shear. The four spores figured by Berkeley are pycnospores and not ascospores, so that it can be confidently stated that the diagnosis of *Cenangium pityum* Berk. & Curt. refers to the pycnidial condition and not to the perfect stage of this fungus."

The locality of the type collection is given only as New England, and the host again is *Abies*.

Shear (**1907**) properly interpreted the structure and described the fungus as *Bothrodiscus pinicola*. In this description the host was said to be *Pinus virginiana*, but this was evidently an error on the part of the collector. Dr. Shear, in a letter, expressed doubt that the host was *Pinus* and sent a bit of the wood from the type collection, and when this was examined microscopically by Dr. M. W. Bannan it proved to be not *Pinus*, but *Abies*.

Naumov (**1915**) reported a conidial fungus on *Abies sibirica* in Russia, which he described as *Pycnocalyx Abietis*. He considered that this fungus was related to *Bothrodiscus pinicola*, but differed in that the conidia became septate, whereas in Shear's description they were said to be continuous.

It has been found in the Temagami collections that the septation of the conidia is very variable, and that the spores may be one to six celled. In this connection Dr. Shear re-examined the original slide of the type of *Bothrodiscus pinicola* and found that the conidia were now perfectly clear and free from guttules, and showed distinctly three to five septa. Thus there can be little doubt but that *Bothrodiscus pinicola* and *Pycnocalyx Abietis* are identical.

The perfect stage was described by Naumov (**1925**) as *Asco-*

calyx Abietis. He had observed it growing on *Abies* in close association with his *Pycnocalyx Abietis* and inferred that the two stages were genetically related, but he did not prove this connection by cultures. His description and figures agree well with the Canadian collections. He mentioned having collected it twice on *Abies*, the apothecia being immature in each case and brought to maturity in a moist chamber in the laboratory. He also stated that he found a mature form on *Larix* once, but he did not state whether or not the imperfect stage was also collected on *Larix*. The evidence so far accumulated regarding the host relations of this fungus in North America would indicate that it is specific to *Abies*. Possibly a closely related form may occur on *Larix*, or further investigation may show that *Ascocalyx Abietis* is not confined to *Abies*.

CULTURAL STUDIES

Cultures were obtained from both ascospores and conidia and were grown on 2 per cent malt extract agar and on sterilized twigs of the host. The cultural characters were similar in both ascospore and conidial cultures. On malt extract agar the growth is slow, the colonies spreading but slightly and tending to become heaped up. The surface of the colonies is downy to felty, often

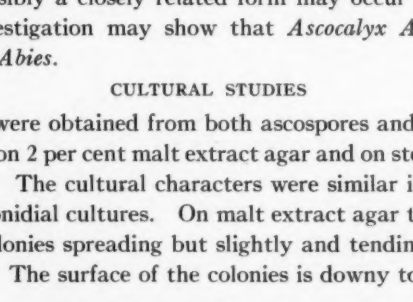

FIG. 2. Photograph of a freehand section of a fruiting body of *Bothrodiscus pinicola*. × 35.

with irregular, white, cottony tufts. The color is variable, from almost white to shades of yellowish-green or olivaceous, "Marguerite yellow" to "buffy olive." Conidial fructifications are produced fairly abundantly in both ascospore and conidial cultures. They are usually typical in form, color, and con-

sistency, of the fructifications found in nature, but sometimes the outside has a downy or tomentose covering. The spore masses are usually very abundant, sometimes forming long cirrhi composed of the small balls of spores.

The twig cultures were set up in the following manner. Three healthy twigs of *Abies balsamea*, about 7–10 cm. in length, were selected and placed in a 300 cc. Erlenmeyer flask with about 25 cc. of water. They were sterilized for half an hour in the autoclave at 15 pounds pressure, and inoculated by placing bits of agar and mycelium in slits which had previously been cut in the bark. The flasks so prepared were kept on a shelf in the laboratory at room temperature and in diffuse light. It was thus possible to remove a twig for examination and leave the others, to observe further development, and also to determine if the perfect stage would develop later. Although after two months fruiting bodies of the imperfect stage were well developed in cultures from both ascospores and conidia, the perfect stage did not appear in any of the cultures, some of which were eight months old.

On the twigs in culture there was produced a thin, cottony, somewhat tufted, aerial mycelium, greyish-green or yellowish-green in color, and sometimes spreading over the twig. Conidial fructifications were formed abundantly in both ascospore and conidial cultures. They were quite typical of those found in nature, sometimes larger, and often covered with a greyish-green tomentum (FIG. 6). The spore masses were usually very abundant, completely filling the cup. Sometimes they did not sporulate, but the stroma elongated into a structure such as that shown at the upper left of figure 6. Sections of this one showed that at the wider central part there was a large cavity with typical pycnidial locules opening into it and spores had been produced, but the peridium had not ruptured and had continued to grow, forming another stalk-like part above the cavity. Others similar to this one have been observed to sporulate at the tip of the second stalk in the usual manner.

Polysporous cultures were used in the hope of facilitating the development of the perfect stage in case the fungus might be heterothallic. However, since the perfect stage did not appear in any of the cultures, there is no information on this point. No microconidia have been observed.

In studying the structure of the fruiting bodies of both perfect and imperfect stages in nature and in culture, freehand sections and crushed mounts have been used entirely. The sections were mounted in cotton blue in lacto-phenol, or stained with eosin or safranin and mounted in glycerine jelly.

TECHNICAL DESCRIPTION

As the Russian article is not readily available, it seems advisable to include a description with synonymy, based on the Canadian material.

ASCOCALYX ABIETIS Naumov. Bolesni Rast. **14**: 138. 1925.

Fusisporium Berenice Berk. & Curt. Grevillea **3**: 147. 1875.
Cenangium pithyum Berk. & Curt. Grevillea **4**: 4. 1875.
Scleroderris pitya Sacc. Syll. Fung. **8**: 596. 1889.
Bothrodiscus pinicola Shear. Bull. Torrey Club **34**: 312. 1907.
Pycnocalyx Abietis Naumov. Bull. Soc. Oural. Sci. Nat. Trud. Bur. Mykol. **35**: 34. 1915.

Apothecia erumpent, scattered, usually in clusters of 3–6, arising from a rounded, black, basal stroma, circular or slightly wavy in outline, slightly narrowed below, 0.3–1.0 mm. in diameter, the clusters up to slightly over 1 mm. in height, dull black externally, hard, leathery to horny in consistency, becoming more fleshy-leathery when moist; hymenium concave, becoming plane, smooth, gray to blackish, somewhat fleshy, surrounded by a light gray margin which is infolded when dry and expanded when moist; tissue of the basal stroma compact, pseudoparenchymatous, composed of irregular cells 6–12 μ in diameter, fairly thick walled, hyaline or pale yellowish, darker toward the outside, the cells becoming more elongated in the stalk and arranged in more or less vertically parallel rows, the upper part containing a zone of dark colored, irregular cells up to 15 μ in diameter, this zone being up to 150 μ thick in the center and curving up around the hymenium, becoming thinner toward the margin; excipulum outside this zone consisting of very thick walled, lighter cells with the walls grown together and the outlines indistinct; subhymenium a zone of closely interwoven, indistinct, yellowish hyphae, 3–6 μ in diameter; asci cylindric-clavate with a very short stalk, eight spored, 65–100 (–125 Naumov) $\times$ 9.5–11.0 μ; ascospores hyaline, elongate-cylindric, to subclavate, tapering slightly toward the ends, one to four celled, mostly straight, irregularly biseriate, 14–22 $\times$ 4–5 μ; paraphyses hyaline, filiform,

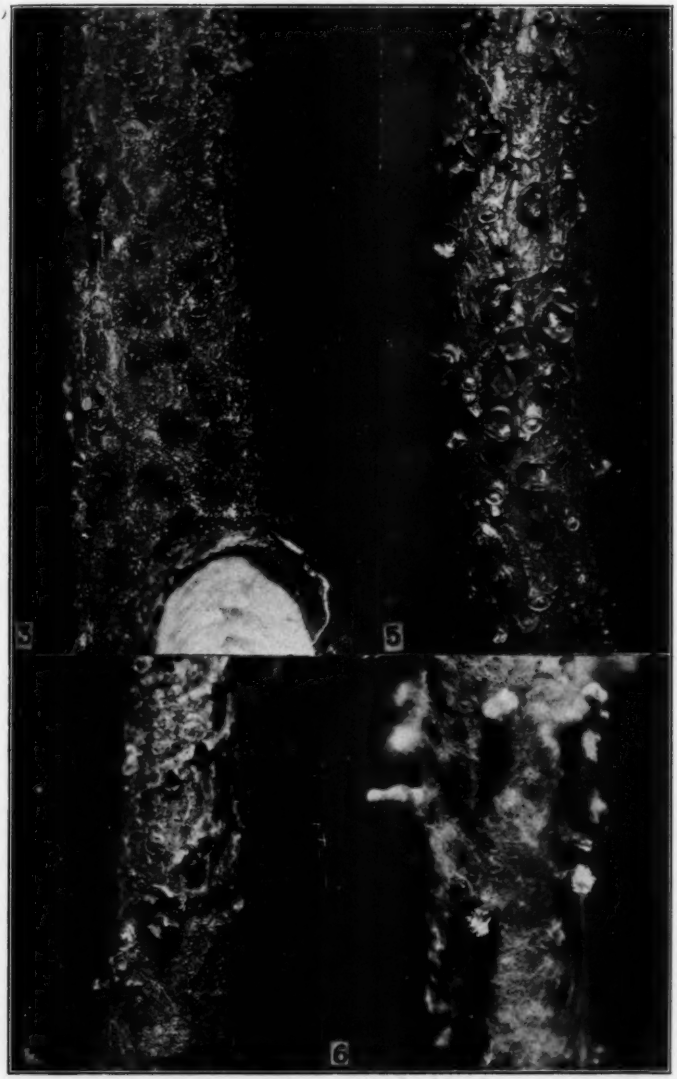

FIG. 3–6. 3, apothecia of *Ascocalyx Abietis;* 4, apothecia opened out after being moistened; 5, imperfect stage, *Bothrodiscus pinicola;* 6, imperfect stage developed on a twig of *Abies balsamea* in culture. × 4 approx.

septate, branched, 1.5–2.0 μ in diameter, scarcely or not at all swollen at the tips, and not forming an epithecium.

Specimens examined. University of Toronto Herbarium. On *Abies balsamea: 7267, 7284, 7285, 7821, 7890, 7893,* Temagami Forest Reserve, Ontario.—*6964,* Bruce Co., Ontario.—Inlet, N. Y.

Conidial stromata erumpent, usually rather thickly scattered, mostly single, or two or three together, occasionally found arising from the same basal stroma as the apothecia, at first almost globose, elongating and becoming obconic, opening at the tip and spreading out, becoming cup-shaped or pezizoid, up to 2 mm. in diameter and 1 mm. in height, externally dark brown to black, sometimes olivaceous when moist, leathery to horny in consistency, becoming more fleshy-leathery when moist; pycnidial cavities immersed in the disc of the stroma, ovoid, about 25–75 $\times$ 75–100 μ; tissue pseudoparenchymatous, composed of irregular cells 5–15 μ in diameter, hyaline or yellowish, becoming darker toward the outside, arranged in more or less vertically parallel rows which spread out obliquely in the upper part, the peridium composed of thicker walled cells which are very dark at the outside; conidiophores hyaline, septate, not observed branching, tapering to a slender point, 8–12 $\times$ 1.5–2.5 μ; conidia hyaline, elongated to subfiliform, ends rounded or rather bluntly pointed, variously curved to almost straight, 1–6 celled, 16–44 $\times$ 3–5 μ, emerging and adhering together in small glomerules.

Exsiccati: Ellis, N. Am. Fung. *376a, 376b.*

Specimens examined. University of Toronto Herbarium. On *Abies balsamea: 4303, 4304, 7284, 7892, 8287,* Temagami Forest Reserve, Ontario.

U.S.D.A. Bur. Pl. Ind. Path. and Myc. Coll. On *Abies Fraseri:* Ex. *60729,* Indian Gap, Great Smoky Mts., N. Carolina. Det. C. L. Shear.

Herbarium University of Michigan. On *Abies balsamea:* F.p. *274,* Isle Royale, Michigan. Coll. and det. A. H. Povah.

U.S.D.A. Forest Pathology. On *Abies balsamea: 50975,* Marlow, New Hampshire. Coll. and det. J. R. Hansbrough.

In the North Carolina and New Hampshire collections, apothecia of *Ascocalyx Abietis* were present, but they were all immature and no asci could be found.

DISCUSSION

Ascocalyx Abietis would belong in the family Dermateaceae as ordinarily interpreted. Naumov (**1925**) suggested that it was close to *Tympanis*, chiefly on the basis of its color and consistency. However, the color is probably not extremely significant, the consistency is really closer to *Dermatea* than to *Tympanis*, and in other characters such as tissue structure, character of the asci and ascospores, and type of conidial stage, it shows no similarity to *Tympanis*. It would seem that *Ascocalyx Abietis* is closely related to the fungi which have been placed in the genus *Crumenula* in the sense of Rehm (**1889**), and that evidence for this relationship is to be found in both the perfect and imperfect stages. Rehm (**1889**) characterized *Crumenula* as including the forms having two to four celled ascospores and fine hairs on the outside of the apothecium. He described two species, *C. pinicola* (Reb.) Karst. and *C. sororia* Karst.

Lagerberg (**1913**) described another species, *C. abietina*, on *Picea excelsa* in Sweden. Many features of this fungus are similar to those of *Ascocalyx Abietis*, the color and consistency of the apothecia, the lighter colored, infolded margin, gray hymenium, and the character of the asci and ascospores. Associated with this discomycete he found an imperfect known as *Brunchorstia destruens* Erikss., which had previously been considered to be the imperfect stage of *Cenangium Abietis* (Pers.) Rehm. He suggested that it might be the imperfect stage of *Crumenula abietina*.

This was proved to be correct by Jørgensen (**1931**) who cultured *Crumenula abietina*, *C. pinicola*, *Brunchorstia destruens*, and *Cenangium Abietis*. He showed that cultures of *Crumenula abietina* and *Brunchorstia destruens* were identical, and while he was unable to obtain any imperfect stage in culture from *C. pinicola* he concluded that it was distinct from *C. abietina*.

No specimens of *C. abietina* have been available for comparison, but the specimen of *C. pinicola* in Rehm's Ascom. *2054* was examined. The material was very scanty, and while the apothecia were of a more reddish-brown color and more hairy than those of *Ascocalyx Abietis*, the asci and ascospores were very similar in appearance but differed slightly in size. A comparison of figure 1b with Jørgensen's figure 10 (**1931**, p. 232) shows the

similarity between asci and ascospores of *Ascocalyx Abietis* and *Crumenula abietina*.

Further evidence for the relationship of *Ascocalyx* and *Crumenula* is provided by a comparison of the conidial stages, *Bothrodiscus pinicola* and *Brunchorstia destruens*. The form of the conidia is very similar in both fungi as may be seen by a comparison of figure 1a and Jørgensen's figure 7, p. 230, and 12, p. 232. Van Luijk (**1927**), who made a study of *Brunchorstia destruens* in culture, speaks of the conidia as issuing in small balls ("pfropfen"), which is a highly characteristic feature of *Bothrodiscus*. The fruiting body of *Brunchorstia* is much smaller than that of *Bothrodiscus*, but is similar in consistency and general structure as determined from an examination of Weese, Eum. Sel. Exs. *701*. It is suggested that the fruiting body of *Brunchorstia* is properly interpreted as a stroma in which only one pycnidial cavity is developed, whereas in *Bothrodiscus* several cavities are formed in the one stroma.

However, while there is good evidence that *Ascocalyx Abietis* is closely related to *Crumenula abietina* and *C. pinicola*, it is thought inadvisable to transfer it to *Crumenula* in view of the present uncertain status of that genus. The genus *Crumenula* was established by DeNotaris (**1861**) based on a fungus collected on *Calluna vulgaris* which he considered to be *Cenangium Urceolus* Fries. This fungus, according to DeNotaris' description, evidently possessed urceolate apothecia and filiform ascospores, and the genus was used in this sense by Phillips (**1893**). The concept of the genus was widened by Karsten (**1869**, p. 170) to include *Peziza pinicola* Rebent., and Rehm (**1889**) emended *Crumenula*, considering *Crumenula pinicola* (Rebent.) Karst. as the type of *Crumenula*, and *Cenangium Urceolus* Fries as the type of the genus *Godronia*. Nannfeldt (**1932**) has combined all these forms under the generic name *Scleroderris*, typified by *Cenangium Ribis* Fries.

The taxonomy of the group is obviously in a state of considerable confusion at present. It is clear, however, that Rehm's treatment of these genera is not in accord with the type concept as defined in the International Rules of Botanical Nomenclature. It may be that *Crumenula* will prove to be a synonym of *Sclero-*

derris, but if the name *Crumenula* is valid it must be reserved for the group of fungi typified by *Crumenula Urceolus* DeNotaris. The writer believes that *Ascocalyx Abietis* is generically distinct from fungi such as *Godronia Urceolus*, as commonly understood, and *Scleroderris Ribis*, but that it is probably congeneric with fungi such as *Crumenula abietina* Lagerberg. Therefore, since it would seem that *Crumenula Urceolus* DeNotaris, the nomenclatural type of the genus *Crumenula*, is not congeneric with *Crumenula pinicola* (Reb.) Karst. and related species, it would appear that the genus *Ascocalyx* is valid for the fungus studied here, and probably also for the species included in the genus *Crumenula* in the sense of Rehm.

SUMMARY

The genetic connection of *Ascocalyx Abietis* Naumov and *Bothrodiscus pinicola* Shear has been established by cultures.

Ascocalyx Abietis is probably closely related and congeneric with the fungi which have been placed in the genus *Crumenula* in the sense of Rehm.

Crumenula, as used in this sense, is not based on the nomenclatural type of the genus, and therefore it is concluded that *Ascocalyx* is a valid genus.

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NOTES ON BOLETES. V

WALTER H. SNELL

In spite of a generally unsatisfactory season in New York in 1935 because of the severe drought, the past year or more has yielded information upon the boletes that is of great interest and importance. This new information has come chiefly from the study of specimens received from other mycologists or collectors. The most interesting material was the following:—several specimens from Pennsylvania, collected by Miss Esther A. Dick, one of the writer's graduate students; a new species and genus from Tennessee sent by Dr. L. R. Hesler; several collections from the environs of Ottawa by Mr. I. L. Connors and Dr. F. L. Drayton; a large amount of material from Manitoba sent by Dr. G. R. Bisby; a few important collections from Florida made by Mr. H. C. Beardslee; and especially a large number of the bolete collections in the University of Michigan Herbarium made by the late Dr. C. H. Kauffman, which were very kindly loaned by Dr. E. B. Mains.

Among the most interesting collections or distributional data not mentioned elsewhere in this paper, may be mentioned the following items.

(1) In New York, near Ausable Chasm, the writer found *Boletus Atkinsoni* and *B. variipes* in quantity, *B. hemichrysus* for his first time, and *B. impolitus*. This latter species was found again at Riverside.

(2) In the Manitoba material there were many species reported heretofore only in eastern North America, and most interesting of all, *B. mirabilis* heretofore known only from Washington and Oregon.

(3) *B. subalbellus* and a species that appears to be *B. albidus* subsp. *eupachypus* was sent in by Mr. Beardslee from Florida.

(4) In the Kauffman material were collections from the Atlantic to the Pacific, providing valuable distributional data, and including a number of new species, mostly tentatively named by him.

Of known species, perhaps the most interesting were *B. mirabilis* from the Pacific Coast, *B. albidus* subsp. *eupachypus* in the East, and *B. edulis* subsp. *pinicola* in Wyoming.

BOLETUS CALOPUS and BOLETUS PACHYPUS

There has long been much uncertainty concerning *B. calopus* and *B. pachypus*. In this country, the uncertainty has concerned their occurrence on this side of the Atlantic. Peck listed them as reported here by others, but he did not collect them. Others have identified them only tentatively. In Europe, the uncertainty has concerned the correct application of the specific names. As might be expected, the clearing up of the situation in Europe has resulted in a clarification of the American situation likewise.

Konrad [1] decided that the name *pachypus* no longer should have a place in mycological nomenclature, because of the confusion resulting from its retention. In brief, he has decided that *B. pachypus* of most writers is *B. calopus* Fries, of which *B. olivaceus* (Schaeff.) Fries is only a synonym. This species has a brownish to olivaceous pileus, and a beautifully reticulated scarlet-, rosy- or purplish-red stipe, usually yellow at the apex. A closely related species is *B. albidus* Roques, pale in color, with stipe pale and not at all red or reticulated. More or less between these two is a species with pileus pale olivaceous to creamy yellowish to hazel, or perhaps cinnamon-brown, and a stipe yellowish at the apex, below dingy yellow more or less tinged or streaked with red, and a dark olivaceous-reddish base. This Konrad calls *B. albidus* subsp. *eupachypus*.

Whatever others may think of this disposition of former difficulties in this group, it works out well with American forms. The correct naming of anything near these species has heretofore been difficult. For example, Kauffman called some of his collections *calopus* and some *pachypus*, after changing his mind one or more times, and finally tentatively named two collections *B. dissimilis* n. sp.—most aptly. I have had similar experiences. In the light of Konrad's work, the situation now seems simple. We apparently have the true *calopus* in this country, but it is rare, and we also most certainly have Konrad's *B. albidus* subsp.

[1] Konrad, P. Notes critiques sur quelques champignons du Jura. Bull. Soc. Myc. Fr. IV, **45**: 35–77. 1929.

eupachypus—or *B. eupachypus* Konrad, as many will prefer to call it. Kauffman's excellent notes, photographs and drawings make it very plain that this species occurs from Nova Scotia to Michigan. What I thought in "Notes on Boletes. I"[2] might be *B. rhodoxanthus* Kalchbr. is possibly this species.

NEW FORMS

The writer hesitates to multiply the number of forms (formae) and varieties with distinctive names, because of the ease with which one develops the habit of interpreting slight variations as definite taxonomic units. On the other hand, there are cases such as those below, in which the variations from the typical manifestation of the species are so definite that there is often a question as to whether or not they are distinct species. In order to avoid the multiplication of the number of species until sufficient information is at hand to make it compulsory, and to use the species concept on broad lines rather than on narrow differences, it seems best to designate the most outstanding of these variations as forms or varieties. In these cases, for the present the word "form" is used instead of "variety" as making no commitment as to the actual status of the variable segregate under consideration, until further information is available.

B. CASTANEUS *f.* **purpurinus** forma nov.

There has been found both by myself in New York and by Kauffman in Michigan a bolete that grows in the same habitat as *B. castaneus*, and is exactly like it except for the reddish-purplish instead of castaneous color, and in the clothing of the pileus being somewhat more pilose-tomentose.

NEW FORMS OF B. FELLEUS

In the writer's experience, the common *B. felleus* is typically partial to soil under hemlocks and to badly rotted hemlock stumps and logs. On the other hand, there are found under oaks and other hardwoods three puzzling forms which resemble *B. felleus* for the most part, especially in their bitter taste, but which seem to be best disposed of as forms of it.

Forma **plumbeoviolaceus** forma nov. was called to the writer's

[2] Mycologia **24**: 334–341. 1 fig. 1932.

attention by A. B. Hatch in the Black Rock Forest near Cornwall, N. Y. It is distinctive as follows:—entire plant very hard and firm, especially when young, never as large as the typical form, pileus tomentose with a velvety appearance, quite violaceous when young and becoming a dull violaceous-purplish-gray or even duller, margin sterile, tubes remaining white for a long time and maturing their spores and becoming flesh-colored only very slowly, and with the stipe pallid to brownish or violaceous and often only very slightly reticulate.

It has since been found by Miss Esther A. Dick near Reading, Penn., and Kauffman also collected it in the District of Columbia and in Tennessee. Kauffman had hesitated between calling it a new species and a variety of *felleus*. Inasmuch as the above name given to it has been used by myself and some friends for some years, I am retaining it instead of changing it to the one Kauffman applied to it.

Forma **rubrobrunneus** forma nov. was found in 1935 under oaks near Round Lake and at Ausable Chasm, N. Y. Like the preceding, it is very firm and hard, and with velvety-appearing surface, sterile margin, and with late-maturing tubes. In color it is dull chocolate-brown to rich deep reddish-brown.

Forma **albiceps** Kauffman forma nov. was tentatively named as a distinct species "near *B. felleus*," but in my opinion it fits into the scheme mentioned above, as here named. It is at first closely mealy on the pileus and then glabrous, and is white throughout. It has been found only in Michigan.

NEW GENUS AND NEW SPECIES

The only parts of this country which have been thoroughly searched for boletes are New York State by Peck, the environs of Brattleboro, Vt., by Frost, and Mt. Gretna, Penn., by McIlvaine. Peck and Murrill named sporadically communicated forms from certain localities in the South, Middle West and the Pacific Coast. The northeastern states are now yielding newly found known species and even some new ones, and the certainty that many new species would be found in other parts of the country as soon as anyone began collecting these fungi there, is being borne out by what follows.

Polyporoletus gen. nov.

Carpophora suberosa, tenace, polyporoidea; tubulis inseparabilibus brevissimis, decurrentibus; stipite paululum crasso, eccentrico; sporis subglobis, brevi-verrucosis vel echinulatis.

Carpophore corky, tough, polyporoid; tubes inseparable, very short, descending the stipe to base in places; stipe stout, eccentric; spores subglobose, short-verrucose or echinulate.

Polyporoletus sublividus sp. nov.

Pileo firmo, suberoso, plano-convexo, e tomentoso fibrilloso, in disco subglabro, livido-olivaceo, in margine rubro-purpuraceo, 5 cm. lato; carne dilute cyanea vel violacea, infra cutem rubro-purpuracea, sapore grato; tubulis difficiliter separabilibus, longe decurrentibus, primo flavis vel ochraceis, deinde brunneis, purpuraceo-tinctis, brevissimis; poris magnis, inaequalibus; stipite eccentrico, subglabro, reticulato, e livido-violaceo purpuraceo, flavo-olivaceo-velutino, spongioso; sporis subglobis, hyalinis, minute brevi-verrucosis, 7–10 μ.

Pileus firm and corky, nearly plane, 5 cm. broad. Surface tomentose on the margin, elsewhere fibrillose, nearly glabrous on disc; livid olive, reddish-purple on the margin. Flesh pale bluish or violaceous, more reddish-purplish under the cuticle; taste pleasant. Tubes hardly if at all separable, long-decurrent, at first yellow or ochraceous, later brownish with a purplish tinge, very short, 1–2 mm. long; mouths large, irregular and more or less uneven. Stipe eccentric, almost lateral, basically nearly glabrous, coarsely reticulate from walls of tubes, in part to base of stipe; basically livid to violaceous-purplish, covered with a yellowish-olivaceous velvetiness in places; within spongy, colored like flesh of pileus; 4 cm. long, 18–25 mm. thick. Spores subglobose, hyaline, minutely short-verrucose or echinulate, 7–10 μ. Cystidia scarce, clavate, few slightly rostrate, hyaline, 35–40 $\times$ 8–10 μ.

On soil in oak-pine woods, near Allardt, Fentress County, Tennessee. Coll. A. J. Sharp and J. K. Underwood; comm. L. R. Hesler *via* L. O. Overholts. No. *536* in Herb. WHS.

This genus is polyporoid in its toughness and corkiness, and short tubes. It also is very close to *Gyrodon* of Europe in its short tubes and more or less dentate pores. It differs from *Gyrodon*, however, in being corky and tough, in having a thick, eccentric stipe, and especially in its subglobose, verrucose spores. These characters seem to provide sufficient justification for the erection of a new genus.

Boletinus squarrosoides Snell & Dick, sp. nov.

Pileo plano-convexo depressoque, cum fuscis, teretibus, fibrillosis squamulis ornato, in margine e tomentoso fibrilloso, badio, 3–7 cm. lato; carne aquoso-flava, brunnescente; tubulis decurrentibus, flavis; poris magnis; stipite subaequale, minutissime furfuraceo, reticulato, flavo, deorsum pileo concolore sed pallidiore; sporis ochraceo-flavis, ellipsoideo-ovoideis, hyalinis sub lente, 7–10 × 3.5–4.5 μ.

Pileus plano-convex and depressed; 3–7 cm. broad. Surface with disc adorned with small to minute, erect, terete, pointed, dark-colored fibrillose scales; perhaps tomentose or glabrescent in spots, margin tomentose to fibrillose; bay-red or dark chestnut to yellowish-brown. Flesh watery in consistency, watery-yellow, changing to chocolate-brownish; odor fungoid; taste none to mild. Tubes decurrent, with the tubes appearing like gills near the stipe, watery-yellow, unchanging, 6 mm. long; mouths concolorous, large, some 3 mm. broad, angular, compound. Stipe subequal, slightly larger at apex; very minutely furfuraceous, reticulate, often to base or only part way and then more or less rugulose, occasionally reticulate only at apex; yellow with reticulation reddish-brown, at base like pileus but paler; within watery-yellow, unchanging; 3–7 cm. long, 5–10 mm. thick. Spores ochraceous-yellow to light melleous in mass, elliptical to perhaps somewhat ovoid, hyaline, 7–10 × 3.5–4.5 μ (mostly 8–9 × 4 μ). Cystidia clavate, fusiform to ventricose-rostrate, hyaline to yellow, 35–60 × 7–10 μ.

Solitary to caespitose, under hardwoods (oaks?). Mt. Neversink, Reading, Penn. Coll. Esther A. Dick, No. *532* in Herb. WHS.

This species has the general appearance and the spores of a *Boletinus*, although the tubes do not strikingly or generally show the radiately arranged tubes and the veins. It is apparently nearest to *B. castanellus*, but differs in the reddish-brown color, the terete scaliness, and the yellow colors of flesh, tubes and stipe.

Boletus chrysenteroides sp. nov.

Pileo convexo vel plano-convexo, sicco, primo minute subtomentoso, deinde flocculoso-fibrilloso-squamuloso vel rimoso-areolato, primo fusco-umbrino vel olivaceo-brunneo, deinde pallidiore vel ochraceo-brunneo, in rimis pallido vel rubescente; carne pallido-flava, sub cutem saepe rubescente, cyanescente, odore saporeque mite; tubulis sinuato-adnatis vel dentato-decurrentibus, depressis, olivaceo-citrinis, deinde olivaceis, demum brunnescentibus, lente cyanescentibus; poris subangularibus, paululum magnis; stipite paulo curvato, saepe ventricoso, striatulo vel rugoso, apici reticulato, e fibrilloso furfuraceo,

apici pallido-flavo, deorsum rubro, basi fusco-umbrino, intra supra pallido, deorsum purpuraceo-rubro et basi umbrino; sporis olivaceo-brunneis, e subfusiformibus late ellipsoideis, in longitudinenem rugosis, 10–17 × 5–7.5 μ.

Pileus convex to plano-convex, 2–8 cm. broad. Surface dry, at first minutely subtomentose, then appressed flocculose-fibrillose-squamulose to rimose-areolate, coarsely so on disc and finer toward margin; at first deep rich brown or olivaceous-brown, later paler even to ochraceous-brown, cracks or interstices creamy to pallid or dingy, perhaps slightly pinkish or reddish. Flesh pallid yellowish or cream-colored, sometimes slightly reddish under the cuticle, changing more or less rapidly to blue, worm-holes and eaten places reddish; odor and taste pleasant and mild. Tubes adnate to sinuate-adnexed and decurrent by a tooth and hence much depressed around the stipe; at first bright lemon-yellow with more or less of a greenish tinge, at length duller and more or less olivaceous, finally dark brownish, changing slowly to bluish, 7–10 mm. long; mouths subangular, medium to large. Stipe usually more or less curved and tapering downward, perhaps ventricose; more or less striate or rugulose, perhaps somewhat reticulate at apex, furfuraceous to fibrillose; apex pallid to pale yellowish, midzone purple-red to brownish-red, and darker to brown at base; within solid, like flesh of pileus at apex, purple-red below, dingy yellowish-white to dingy brown at base, changing more or less to bluish; 3–9 cm. long, 3–15 mm. thick. Spores deep olivaceous-brown in mass, broadly elliptical to almond-shaped or subfusiform, brownish-yellow under the microscope, *longitudinally wrinkled*, 10–17 × 5–7.5 μ, mostly 12–14 × 6–7 μ. Cystidia clavate-ventricose to ventricose-rostrate, hyaline, abundant, 35–70 × 10–14 μ. Mycelium white.

Under hemlocks and mixed hardwoods, presumably where oaks were once present. Province of Quebec to mountains of North Carolina and west to Michigan. Type no. *412* in Herb. WHS, from Enfield Gorge near Ithaca, N. Y.

This puzzling species was first collected by I. L. Connors at Mt. Burnet, Quebec, in 1934, but reached the writer in a badly broken condition. At the Mycological Foray at Ithaca in 1935, several specimens that in the field were called *B. chrysenteron*, were found to have the same longitudinally rugose or wrinkled, large, ellipsoid spores that were present in Connors' specimen. These specimens also resembled Peck's *B. fumosipes* in most particulars and it was then recalled that the same sort of spores had been found in Peck's types at Albany. Hence, it seemed cer-

tain that the species must be *fumosipes*, even though certain characters of this species were lacking in the newly collected plants.

When Peck's types of *B. fumosipes* at Albany were carefully studied, however, a strange situation was revealed:—some of the sporophores had broad, wrinkled-rugose spores and others had smooth and somewhat narrower spores. At first it was naturally believed that the difference in spores was probably due to a difference in maturity of the fruit bodies. The writer could not, however, convince himself that such was the case, for the following reasons:—(1) both the wrinkled-spored fruit bodies and the smooth-spored ones had cast spores in large numbers, and apparently were mature; (2) neither sort had spores of the other kind whereas one would ordinarily expect to find a mixture, if smooth ones later became wrinkled; (3) in mounts of spores from each group of fruit bodies, there can be found some hyaline spores with the colored ones, but they are the same in each mount—i.e., the hyaline ones in the mount of wrinkled spores are wrinkled like the colored (mature) ones and not smooth as one might expect if they were immature. It should be added that the smooth spores of *B. fumosipes* show a faint suggestion of lines and much time was spent in an endeavor to become convinced that these were only immature spores that would later have become wrinkled. These spores were examined at various magnifications, in different mounting media and with several kinds of light, including monochromatic lights, with the result that these vague lines seem to be entirely due to diffraction of light passing through the spore and are not wrinkles, markings or elevations on either the inside or the outside of the spore wall. The wrinkles of the truly wrinkled spores are on the outside of the wall and not on the inner surface.

B. fumosipes and this suggested new species are almost identical in macroscopic characters. The only differences thus far observed are as follows:—*chrysenteroides* has no bluish or greenish zone at the apex of the stipe; it has greenish-yellow tubes while *fumosipes* has greenish-white to pallid straw-colored tubes; it has wrinkled-rugose, rather deep yellow-brown spores, 6–8 μ thick while *fumosipes* has smooth, pale brownish spores 5–5.5 μ thick, except for occasional giant ones; the cystidia of *chrysenteroides* are likewise thicker than those of *fumosipes*.

Thus, with some misgivings and after much uncertainty over many months, it has been decided that on the basis of these characters, the naming of a new species is justified. It belongs in the Subtomentosi, near *chrysenteron*, if the Friesian scheme is followed.

Boletus peralbidus Snell & Beardslee, sp. nov.

Pileo firmo, convexo, sicco, glabro vel subglabro, in maculis paene subtomentoso, albo, pallido-brunnescente, 3–6 cm. lato; carne alba, paululum brunnescente; tubulis adnatis, depressis, albis, fractis brunnescentibus; poris parvis, rotundis; stipite firmissimo, deorsum fastigata, aequo, minute furfuraceo, albo, paulo brunnescente; solido, intra albo; sporis e elongato-oblongis subcylindricis, sub lente hyalinis, 7–12 × 2.5–3 μ.

Pileus firm, convex, 3–6 cm. broad. Surface dry, glabrous or nearly so, almost subtomentose in spots, white, becoming pale brownish or dingy whitish with age. Flesh white, dingy brownish when cut, up to 10–15 mm. thick. Tubes adnate, deeply and narrowly depressed, white becoming dingy-brownish when cut; mouths small, rotund. Stipe unusually firm, mostly tapering downward, even, minutely furfuraceous, white, the mealiness becoming ochraceous-brownish, staining brownish where wounded; within solid, white; 3–4 cm. long, 10–14 cm. thick. Spores probably pale ochraceous in mass, subcylindrical to elongate-oblong-elliptical, hyaline, 7–12 × 2.5–3 μ, mostly 8–10 × 2.5 μ. Cystidia abundant, glutinous and often incrusted with spores, fusiform, dingy yellow or yellowish-brown with hyaline apex, 35–50 × 7–10 μ.

Altamonte Springs, Florida. Coll. H. C. Beardslee. No. *529* in Herb. WHS; *35,167* in Herb. HCB.

There are only a few really white species of *Boletus*. In a few cases, occasional specimens of certain species are found bleached by the rain. Some of these are in the group with viscid pileus. Other than these Viscipelles, there are only four white species. *B. frustulosus* is southern, and distinctly frustulose. *B. subalbellus* has a hollow stipe and rather broadly elliptical spores. *B. albellus* and *B. niveus*, of the *scaber* group, have large fusiform spores, more or less colored. *B. peralbidus* is distinguished, therefore, from most species by its whiteness throughout, and from the white forms by its general smoothness, its solid stipe and its narrowly cylindrical spores. It is placed tentatively in the Versipelles in spite of the aberrant spores.

Boletus scabroides Kauff. sp. nov.

Pileo plano-convexo, recente paululum viscido, aequo, glabro, in maculis minute rimoso, isabellino vel ochraceo-brunneo, 6–10 cm. lato; carne molle, e pallida flavo-albida, paululum cyanescente, odore saporeque mite; tubulis adnatis, depressis, flavovirentibus, vix cyanescentibus; stipite e substriato aequo, subreticulato, minute furfuraceo vel minute scabro, apici citrino, deorsum pallido-brunneo vel flavo rubrotincto, rubro-furfuraceo, intra flavo, lente cyanescente; sporis sub lente pallido-flavovirentibus, subfusiformibus, 11–15 × 2.5–5 μ.

Pileus convex to plane, 6–10 cm. broad. Surface slightly viscid when fresh, even, glabrous, minutely rimose in spots; pale tan, ochraceous cinnamon, or brown ochraceous. Flesh soft, whitish to pale yellowish, changing slightly to bluish or not at all changing; taste and odor mild, except surface bitter. Tubes adnate, becoming depressed and half adnate, as long as flesh is thick; greenish-yellow, becoming sordid greenish-yellow in age, scarcely changing to blue; mouths angular, some more or less compound, 1–2 mm. Stipe even to somewhat striate, tending towards reticulate, minutely furfuraceous to scurfy or minutely scabrous except at apex; citron yellow at apex and chrome yellow at base, in between pallid tinged brownish or perhaps mostly yellow tinged reddish, with the scurf sometimes reddish; within yellow, changing very slowly to pale blue; 5–9 cm. long, 6–20 mm. thick. Spores very pale greenish-yellow under the microscope (in old specimens), subfusiform, 11–15 × 3.5–5 μ, some to 18 μ, mostly 12–14 × 4–4.5 μ.

Solitary, in hemlock or spruce woods or swamps. Ann Arbor, Michigan. Coll. C. H. Kauffman. No. *562* in Mich. Herb.; *451* in Herb. WHS.

This species seems to belong in the Subpruinosi, in the absence of stuffed tubes. It is distinguished by the pale tan to brownish-ochraceous colors of the pileus, stipe yellow at apex and base, and scurf usually reddish. It is nearest to *B. glabellus*, from which it differs in the stipe characters, and the glabrous pileus.

Boletus plumbeotinctus Kauff. sp. nov.

Pileo late convexo, obtuso, viscido, demum ruguloso, primo "clay color," mox "dark olive gray," 7–8 cm. lato; carne firma, crassa, alba, odore saporeque mite; tubulis adnatis, subdepressis, paucis decurrentibus, inaequalibus, "mustard yellow"; poris angularibus; stipite breve, subaequale, leve, glabro, albo, apici pallido-flavo, solido intra albo; sporis anguste ellipsoideis vel subcylindricis, sub lente e pallido-flavis hyalinis, 7–9 × 2.5 μ.

Pileus broadly convex, obtuse, edge extending beyond tubes, 7–8 cm. broad. Surface *viscid*, even, becoming rugulose from the drying gluten, at first clay color, soon dark olive-gray (R). Flesh firm, thick compact, white, unchanging; taste and odor mild. Tubes adnate, subdepressed, few decurrent, uneven, with projecting tongues, mustard-yellow, 5–7 mm. long; unchanging; mouths angular, 2–3 a mm. concolorous. Stipe short, subequal, even glabrous, white, pale yellowish at apex; within solid, white; 3.5 cm. long, 15–20 mm. thick. Spores narrowly elliptical or subcylindric, hyaline to perhaps very pale yellowish, 7–9 × 2.5 μ, mostly 7–8 μ long.

Under spruce and pine. Leal, Colorado. Coll. C. H. Kauffman. No. *560* in Mich. Herb.; *485* in Herb. WHS.

This species belongs in the Viscipelles and is distinguished by colors of the pileus (clay color to dark olive gray), stipe yellow at apex and white below, and the small spores.

Boletus rubescentipes Kauff. sp. nov.

Pileo convexo, sicco, leve, glabro vel subpruinoso, vix subtomentoso, primo "dingy buff-whitish," deinde "dingy avellaneous," 5–10 cm. lato; carne alba, fracta subrubescente, sapore mite; tubulis adnato-depressis, vix decurrentibus, primo pallido, deinde "deep colonial buff," demum "ecru olive"; poris angularibus; stipite fortasse deorsum fastigato, leve, glabro, concolore vel pallidiore, intra albo, subrubescente; sporis brunneo-olivaceis, subfusiformibus, sub lente pallido-olivaceis vel flavovirentibus, 8–12 × 4–5.3 μ.

Pileus convex, 5–10 cm. broad. Surface dry, even, glabrous or subpruinose, hardly subtomentose, at most only very obscurely and very minutely so, at first dingy buff-whitish, then dingy avellaneous or pale brownish and mottled with small darker drop-like spots. Flesh white, becoming faintly dingy pinkish when cut, taste mild, odor none. Tubes adnate-depressed, hardly decurrent, at first pallid, slowly deep colonial buff, finally ecru-olive from spores, 5–9 mm. long; mouths angular, often subsinuate by coalescence of two, about 2 a mm. Stipe perhaps tapering downward, curved at base, even, glabrous, concolorous or a little paler in color, changing to more or less pinkish when rubbed; within white, turning dingy pinkish; 5–7 cm. long, 7–15 mm. thick. Spores light brownish-olive to brownish-olive in mass, subfusiform and narrowed on one side at distal end, pale olivaceous to slightly greenish-yellow, 8–12 × 4–5.3 μ, mostly 9–11 × 4–4.5 μ. Cystidia narrow, hyaline fusiform or obtuse, 50–70 × 6–10 μ. Subhymenial bodies, deep yellow, obtuse, 25–30 × 12–15 μ.

Mt. Gretna, Penn. Coll. C. H. Kauffman. No. *570* in Mich. Herb.; *487* in Herb. WHS.

This belongs in the Subpruinosi and is distinguished by the buffish colors of the pileus, and the flesh of pileus and stipe turning pinkish to reddish.

Boletus subclavatosporus sp. nov.

Pileo convexo vel plano-convexo, sicco, e subpruinoso glabro, rare minute subtomentoso, in maculis minute rimoso-areolato, "dingy warm buff," 5–10 cm. lato; carne sordido-alba, cyanescente, decolorante, sapore felleo; tubulis e subdecurrentibus adnatis, subdepressis, primo albis vel pallido-stramineis, demum pallido-flavo-olivaceis, fractis brunneo-olivaceis; poris rotundis vel subangularibus; stipite gracile, subaequale, leve, glabro vel obscure furfuraceo-punctato, e tubulis subreticulato, subconcolore, intra supra sordido-albo, deorsum sordido-rubro; sporis late clavatis vel subclavatis, paucis subcylindricis, pallido-olivaceis sub lente, 11–14 × 4–4.5 μ.

Pileus convex to plano-convex, 5–10 cm. broad. Surface dry, glabrous to subpruinose, rarely minutely and obscurely subtomentose, in places minutely rimose-areolate, dingy warm buff. Flesh dingy white, *turning King's blue when cut*, sometimes deeper blue, fading again, 15 mm. thick; taste *bitter*. Tubes convex, adnate to slightly subdecurrent, more or less depressed, at first white or very pale yellowish-white, becoming at maturity light yellowish-olive, brownish-olive where bruised, 5–9 mm. long; mouths rotund to subangular, 2–3 a mm. when young, 1–2 when older. Stipe medium slender, equal or nearly so, even, glabrous or obscurely scurfy-dotted except at apex where it is slightly reticulate from decurrent walls of tubes, slightly paler than pileus; within dingy white above, dingy reddish in lower half, unchanging; 6–12 cm. long, 8–15 mm. thick. Spores probably brownish-olivaceous in mass, broadly clavate or subclavate, with one end narrowed, few somewhat narrowly diamond-shaped, few subcylindric, pale olivaceous or slightly olivaceous-yellow tinged, 11–14 × 4–5 μ. Cystidia abundant, often clustered, fusiform, hyaline, 40–60 × 4–8 μ.

Subcespitose or gregarious along river. Hot Springs, North Carolina. Coll. C. H. Kauffman. No. *556* in Mich. Herb.; *488* in Herb. WHS.

This belongs in the Subpruinosi and is distinguished by the buff color of the pileus, the bitter taste of the flesh and its change to bright blue, the white or whitish color of the tubes when young, the reddish color of the stipe within downwards, and the subclavate spores.

ERRORS CORRECTED

In "Notes. II" (pp. 220–231) [3] it was argued that *B. isabellinus* Peck is probably not the same as *B. Ananas* M. A. Curtis, as maintained by Murrill, but more likely the same as *B. subalbellus* Murrill, from the same locality. Further study of the specimens available, however, has convinced the writer that he was wrong and that Murrill was right.

In "Notes. I" (pp. 335–336) [4] it was stated that in all probability, *B. sordidus* Frost is the same as *B. porphyrosporus* Fries. This statement is likewise an error, because of the difference in the spores. It is much more likely that *B. sordidus* and *B. fumosipes* Peck are the same plant, but this remains to be demonstrated.

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[3] Snell, Walter H. Notes on Boletes. II. Mycologia **25**: 221–232. 1933.
[4] Snell, Walter H. Notes on Boletes. I. Mycologia **24**: 334–341. *1 fig.* 1932.

THE LIFE HISTORIES OF BOTRYOSPHAERIA MELANOPS AND MASSARIA PLATANI

C. L. Shear and Ross W. Davidson

(with 5 figures)

Among the specimens sent into the Washington laboratory of the Division of Forest Pathology for identification, there are occasional fungi of more than ordinary interest, either because of their scarcity or because, in the course of the work incidental to their identification, some new information is secured regarding them. These criteria apply to specimens of the two fungi with which this paper is concerned.

Botryosphaeria melanops (Tul.) Wint.

Botryosphaeria melanops was collected on red oak, *Quercus borealis*, in Meshomasic State Forest, Connecticut, September 27, 1935, by Bailey Sleeth (F.P. No. *67,970*). This fungus is apparently not common in Europe and has not been reported previously in America, according to the Farlow Index, which was very kindly examined by G. D. Darker. Moreover, until now its life history has been based entirely on the association of the different spore forms on the host. The material sent in was abundant. The ascospores measured 31–48 × 14–21 μ, mostly 34–36 × 16–18 μ; macropycnospores 41–53 × 9–11 μ, mostly 47–50 × 10–10.5 μ.

Tulasne (**4**) first described and illustrated this fungus completely in 1863. He found ascospores and macro- and micropycnospores all in the same stroma, which would seem to be fairly reliable proof of the genetic relation of the three spore forms; yet confirmation by pure cultures, even in such cases, seems desirable. Tulasne stated that he found the fungus common on cut branches of oak in the vicinity of Paris. The only other reference he made to specimens was to Fries, Scler. Suec. Exs. No. *143*, 1821. On page 298 l. c. he stated that the specimen of this number he examined had only macropycnospores,

which are especially characteristic in this species. He also said that Cesati and DeNotaris had referred the same specimen to *Ascoxyta Quercus* Lib., Crypt. Ard. No. *46*, 1863. We have not had an opportunity to examine Libert's specimen. A specimen of this same number of Fries exsiccatae which we have examined also shows typical macropycnospores of *B. melanops*.

Only two somewhat doubtful European specimens of this species that we have seen show ascospores. No. *1547*, C. Roumeguere, Fung. Gall. Exs. collected in Malmedy, Belgium, by Libert and labelled *B. advena* (C. & D.) on oak, has ascospores in the specimen in The New York Botanical Garden Herbarium set. They are 30–33 × 12–15 μ, and have the typical shape of the spore in this species. No pycnidia were found associated with them. These spores it should be noted are somewhat smaller than the average, as given by Tulasne (**4**), Schroeter (**2**), and Winter (**6**), and also as found in the specimen from Connecticut. The other specimen was distributed by Petrak, No. *107* Fl. Boh. & Morav. Exs., on *Quercus Robur*, Weisskirchen, 1912, as *Botryosphaeria melanops* (Tul.) Wint. The specimen of this number in the mycological collections of the Bureau of Plant Industry shows one piece of oak bark having good *Botryosphaeria* stromata with asci and ascospores. The spores are somewhat rhomboid, become brown when old and measure 27–36 × 12–15 μ, mostly 30 × 14 μ. On this same piece of bark, however, closely associated with the perithecial stromata are others showing macropycnospores of *Dothiorella* very variable in shape, mostly 10–12 × 5–6 μ. Sometimes when mature they are longer and somewhat allantoid, 15 × 18 × 5–6 μ. These, it will be noted, are quite different from the macropycnospores of *B. melanops*. All the other four or five pieces of this specimen show the same *Dothiorella* stromata and spores, but no ascospores. If these pycnospores belong to the closely associated *Botryosphaeria*, it must be a different species from the *B. melanops* (Tul.), which, as already noted, has macrospores four or more times as long. This case, as we have observed before in species of *Botryosphaeria* and *Physalospora*, shows the difficulty of identifying the species from ascospores only; as species having similar ascospores sometimes have quite different macropycnospores. Hence, neither of the two asco-

genous specimens just mentioned can be said with certainty to be true *B. melanops*. In the present state of our knowledge of this and related species, the most dependable character for identifying this species is that of the macropycnospores, which far exceed in size any others at present known. The following specimens which we have examined show macropycnospores of this species:

No. *2363* Fuckel, Fun. Rhen. issued as *Melanops Tulasnei* Nitschke, which shows only macropycnospores 40–45 × 8–10 μ.

No. *1896* Krieger, Fun. Sax. Exs. on *Quercus*, Saxony, May, 1886, issued as *Dothiorella advena* Sacc. shows only macropycnospores 43–52 × 8.5–10 μ which become yellowish brown when old and evidently belong to *B. melanops* (Tul.). Of course, there is the possibility that there is another species of *Botryosphaeria* having similar macropycnospores. Rabenhorst, Fun. Europ. No. *1034* labelled *Dothidea melanops* forma *pycnidifera* on oak shows only micropycnospores according to the specimen of this number in the mycological collections of the Bureau of Plant Industry and it is therefore uncertain whether they belong to this species or to one of the others found on this host.

It would seem, judging from the scarcity of specimens in the larger herbaria, that the species is not common in Europe. However, Schroeter (**2**) reported specimens from four or five localities, and Traverso (**5**) gave three localities in Italy. Our lack of knowledge of the distribution of this and related species of *Botryosphaeria* and *Physalospora* is due in part to the ease with which the various species are confused or overlooked in the field, as there are at least two or three species of *Physalospora* and an equal number of *Botryosphaeria* occurring on oak with their pycnidial forms, whose general macroscopic appearance is so similar as to make it difficult if not impossible to recognize them with certainty without microscopic examination. Many more collections and more study of this group are needed in order to determine the number and distribution of the species in this country as well as in Europe.

The synonymy so far as we know it at present is as follows:

ASCOGENOUS FORM

Dothidea melanops Tul. Ann. Sci. Nat. IV, **5**: 116, 1856.
Melanops Tulasnei Nitschke in Fuckel. Symb. Myc. 225. 1869.
Botryosphaeria advena Sacc. Michelia **1**: 42, 1877, not Ces. and DeNot. 1863 sec. Wint.
Botryosphaeria melanops (Tul.) Wint.; Rabenh. Krypt.-Fl. 1^2: 800. 1887.

PYCNIDIAL FORM

Sphaeria quercina Fries as represented in Scler. Suec. Exs. No. *143*, not Pers.
Dothiorella advena Sacc. Michelia **2**: 620, 1882.
Fusicoccum testudo v. Höhn. Ann. Myc. **1**: 399. 1903. The *Dothiorella* stage.

LIFE HISTORY

Single-ascospore cultures made from the specimen from Connecticut by Mrs. A. F. Kempton, Bureau of Plant Industry, and grown on corn meal in flasks after seven or eight weeks in a cool greenhouse produced scattered subspherical pycnidia 1 to 3 mm. in diameter, containing abundant macropycnospores of *Dothiorella advena* Sacc., averaging about $52 \times 10\ \mu$. They were more uniform in size, but otherwise identical with those found associated with the ascogenous form on the specimens. No micropycnospores were found on the specimen or in the cultures.

An outstanding characteristic of *Botryosphaeria melanops* was its slowness of growth in culture as compared with other fungi of this group, or indeed with many fungi which the writers have studied. *B. melanops* does not seem to be particularly limited, however, in its temperature range or especially restricted as to culture media; it merely grew very slowly on all the media tried. For example, at 20° C. on corn-meal agar plates its average growth was 0.7 mm. per day as compared to 3.5 mm. per day for *B. Ribis*.

Ascospores of *B. melanops* required two or three days to germinate. Under the environmental conditions and on the various culture media which have been found favorable for fungi of this group, six weeks was required for the production of pycnospores. Further development was also very slow. A 3-months-old culture on corn-meal flasks in a cool greenhouse still had a considerable number of pycnidial stromata filled with

young normal-appearing macropycnospores. In the culture of *B. Ribis* of the same age the pycnidia would usually have been empty and the pycnospores long since germinated.

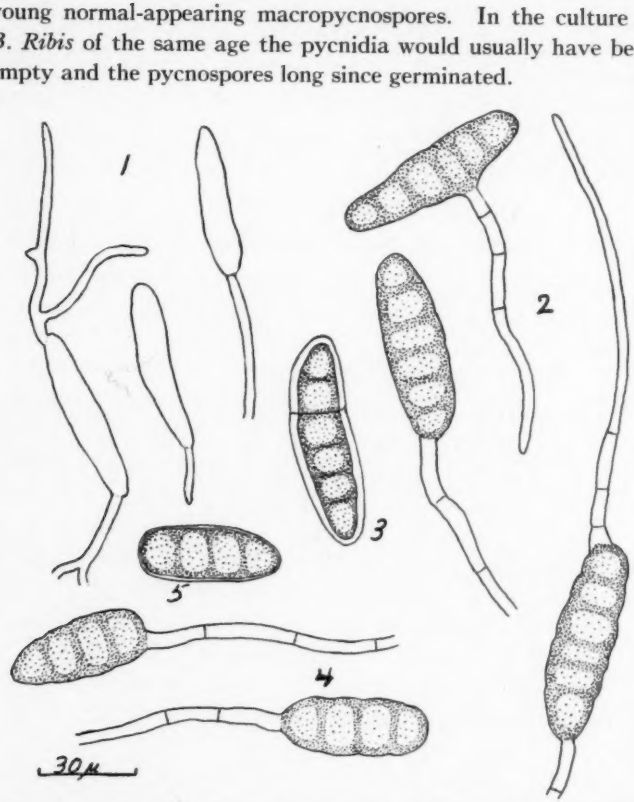

FIG. 1–5. 1, germinating macropycnospores of *Botryosphaeria melanops;* 2, germinating ascospores of *Massaria Platani* with a normal ascospore shown in figure 3; 4, germinating pycnospores of *Massaria Platani;* 5, a normal pycnospore of this same fungus.

Macropycnospores germinated readily on corn-meal agar (FIG. 1) and produced cultures which are similar in every respect to those obtained from ascospores.

MASSARIA PLATANI Ces.

Specimens of *Massaria Platani* were collected on a sycamore tree in Washington, D. C., December 18, 1934, by Bowen Crandall (F.P. No. *59149*). The ascogenous stage was fruiting

in abundance around a branch stub. A diffuse type of canker was forming along the living stem with the pycnidial (*Hendersonia*) stage fruiting in abundance on the outer edges. A slight brown discoloration extended down into the dead and dying sapwood underneath the canker.

This is a common species in this vicinity, but its life history has been merely assumed from the association of the two spore forms, and as this collection contained an abundance of both stages in good fruiting condition it was thought advisable to obtain cultures from both ascospores and pycnospores. The ascospores were mostly 6-celled and measured 58–68 × 14–16 μ. The pycnospores were 4-celled and measured 44–52 × 17–20 μ. These agree well with measurements given in the descriptions of *Massaria Platani* Ces. and *Hendersonia Desmazieri* Mont., and with herbarium specimens of them.

An examination of part of the type specimen of (**3**) *Stilbospora quadriseptata* Schw. found in Michener's herbarium shows that it is the same as *Hendersonia Desmazieri* Mont. Berlese (**1**) stated that *Massaria atroinquinans* Berk. & Curt. according to the original specimen which he examined is the same as Cesati's species. A Curtis specimen of this which we have examined has all the macroscopic characters of this species, but it is old and no ascospores could be found.

The synonymy of the species is as follows:

ASCOGENOUS FORM

Massaria Platani Ces. in Rab. Fun. Europ. Exs. Ed. 2, no. *323*. 1861.

Sphaeria Pupula Fries (p.p.) Syst. Myc. **2**: 484. 1823 sec. Berl.

Massaria atroinquinans Berk. & Curt. Grevillea **4**: 156. 1876.

?Massaria semitecta Berk. & Curt. Grevillea **4**: 147. 1876. sec. Berl.

PYCNIDIAL FORM

Stilbospora quadriseptata Schw. Trans. Am. Phil. Soc. II. **4**: 299. 1832.

Hendersonia Desmazieri Mont. Ann. Sci. Nat. Bot. III. **12**: 310. 1849.

Steganosporium Platani Preuss, Fun. Hoyersw. Linn. **26**: 723. 1853.

Hendersonia Platani Peck, Rep. Bot. N. Y. St. Mus. **25**: 86. 1873.

LIFE HISTORY

Both the ascospores and pycnospores germinated readily on corn-meal agar in 24 hours (FIGS. 2, 4). Single-ascospore and single-pycnospore cultures grew very slowly on malt-extract agar and appeared identical in every respect.

After 5 to 7 weeks growth on malt agar at room temperature of about 24° C. the ascospore cultures produced pycnidia containing pycnospores. These pycnospores were more irregular in shape and size than those produced in nature but in other respects were similar. Pycnospores produced by the pycnospore cultures were indistinguishable from those produced by ascospore cultures.

This fungus is somewhat similar to *Botryosphaeria melanops* in cultural characteristics as it grows very slowly on agar media and has the same color and general appearance of the mycelium. On malt agar at ordinary room temperature it grows even more slowly than *B. melanops*, but on corn meal in flasks at the same temperature it grows at an average rate of 1.8 mm. per day, which is about twice that of *B. melanops* under the same conditions.

DIVISIONS OF MYCOLOGY AND DISEASE SURVEY AND FOREST PATHOLOGY, BUREAU OF PLANT INDUSTRY

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NEW AND UNUSUAL DISCOMYCETES OF WESTERN WASHINGTON

LEON C. SNYDER

(WITH 3 FIGURES)

While preparing his doctor's thesis, "The Operculate Discomycetes of Western Washington," the author collected and identified 72 species of the above group. Many of these are common and widespread forms, others are new or rare and should therefore be of special interest.

1. ASCOBOLUS CARBONARIUS Karst.

Collected only once on charred leaves and twigs where a brush pile had been burned. Redmond, March 10, 1934.

This species is of interest because of its habitat and beautifully warted, brown spores.

2. ASCOBOLUS VIRIDULUS Phill. & Plow.

Collected on the dung of a wild animal, possibly a squirrel. Edmonds, Feb. 10, 1934.

This species has formerly been reported only on the dung of dogs and birds. The apothecia examined were larger than those usually described, reaching a diameter of 3–4 mm. The size of the spores and spore sculpturing were however the same.

3. HELVELLA CRISPA (Scop.) Fries.

On soil in open woods near Seattle from October to December.

This species has been collected in close association with *H. lacunosa* and all gradations between snowy-white and almost black have been found. A more careful study is needed to determine whether our western form is a distinct species or only a variety of *H. lacunosa*.

4. HUMARINA CONVEXULA (Pers. ex Fries) Seaver.

Collected only once on burnt ground among moss near Bothell, Feb. 23, 1935.

This rare and beautiful species is characterized by its small size, convex hymenium, and bright orange color.

5. **Humarina macrocystis** (Sacc.) comb. nov.

Peziza macrocystis Cooke, Mycographia 36. 1875.

Apothecia scattered, shallow cup-shaped to discoid, reaching a diameter of 5–8 mm., externally dull-orange, attached by a broad base with flexuous mycelial hairs; excipulum composed of large thin-walled cells up to 30 microns in diameter; hymenium bright-orange, plane; asci cylindrical, with a narrowed base, 225–250 × 13–14 microns, 8-spored; spores 1-seriate, narrow-ellipsoid, smooth, 7–10 × 18–21 microns, containing two conspicuous oil-drops; paraphyses enlarged above to 6–8 microns, containing orange granules.

On burnt ground among moss. Seattle, Feb. 3, 1935.

This species has not been reported before for the United States. It agrees well with the description in "British Fungus Flora" by Massee.

6. **Lamprospora fulgens** (Pers.) comb. nov.

(*Pseudoplectania fulgens* (Pers.) Fuckel, Symb. Myc. 324. 1869.)

On soil in coniferous woods. Lake Keechelus, May 5, 1934.

This species is usually placed in the genus *Pseudoplectania*. It lacks the black color, cartilaginous texture and well developed hairs of the other two species of the genus. The poorly developed hairs do not exclude it from the genus *Lamprospora* as the outer cells of many of the *Lamprospora* species run out into clavate outgrowths.

7. **Lamprospora pyrophila** sp. nov.

Apothecia scattered to gregarious, sessile, at first globose, becoming expanded and discoid, with an even margin, reaching a diameter of 3–5 mm., externally smooth, salmon-pink; excipulum consisting of interwoven, swollen-celled hyphae; hymenium plane, smooth, salmon-pink; asci cylindrical, 150–200 × 10–12 microns, 8-spored; spores 1-seriate, globose, 7–9 microns in diameter, smooth; paraphyses filiform, hooked at their apices, often forked.

On burnt ground. Canyon Park, Bothell, Feb. 25, 1934;

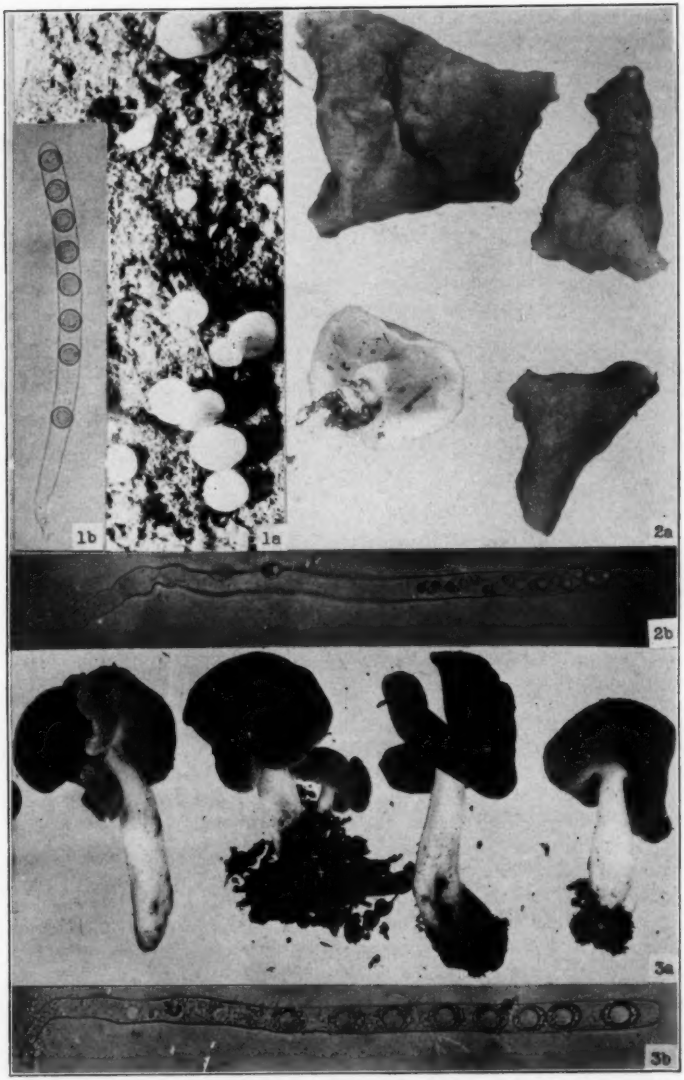

FIG. 1a, habit sketch of *Lamprospora pyrophila*, × 2; 1b, ascus of *L. pyrophila*, × 333; 2a, *Paxina recurvum*, × 1½; 2b, ascus of *P. recurvum*, × 266; 3a, *Paxina compressa*, × ⅔; 3b, ascus of *P. compressa*, × 200.

Redmond, March 10, 1934; Spanaway Lake, Tacoma, March 2, 1935.

This is a very beautiful and common species in the spring, being found where brush has recently been burned. It differs from *L. carbonaria* in its smaller spores which lack the prominent oil drop.

Apothecia sparsa aut gregaria, sessilia, primum subglobosa, disciformia eventa, margine integra, 3–5 mm. in latitudine, exteriter levia, "salmon-pink"; excipulum de hyphis intermixtis cellarum tumidarum; hymenium planum, leve, "salmon-pink"; asci cylindracei, 150–200 × 10–12 microns, octospori; sporidia monosticha, globosa, 7–9 microns in latitudine, levia; paraphyses filiformes, apicibus suis incurvatae, saepe divisae.

In carbonicola. In venta Februario et Marte per Washington ad septentriones, Amer. bor.

8. PATELLA ABUNDANS (Karst.) Seaver.

On coke and burnt ground. Canyon Park, Bothell, Feb. 25, 1934.

Our western form is much larger than the Eastern or European species, frequently reaching a size of 1 cm. The color, spore characters, and hairs agree well with the description given by Seaver.

9. **Paxina compressa** sp. nov.

Apothecia scattered, stipitate, laterally compressed, becoming irregularly lobed, reaching a diameter of 3–4 cm., externally grayish white, covered with fascicles of loosely interwoven hairs; hairs consisting of swollen cells, reaching a diameter of 20–30 microns; stalk white, 4–5 cm. long, up to 1 cm. wide at the base and 5–8 mm. wide where the stalk joins the apothecium, very slightly lacunose; hymenium grayish brown, wavy, smooth; asci cylindrical, 350–400 × 14–16 microns; spores ellipsoid, containing one very large oil-drop and numerous small ones, 13–19 × 23–25 microns, smooth; paraphyses filiform, slightly enlarged above to 3–6 microns.

On the ground in deep woods. Easton, May 5, 1934.

This is a border-line species between *Paxina* and *Helvella*. The white stalk and laterally compressed apothecium are the distinguishing characters.

Apothecia sparsa, stipitata, lateraliter compressa, eventa inique lobula, 3–4 cm. in latitudine, exteriter "grayish white," tomentosa; stipes albus,

4–5 cm. in longitudine, 5–10 mm. in latitudine, lacunosissimus; hymenium "grayish brown," iniqum, leve; asci cylindracei, 350–400 × 14–16 microns; sporidia ellipsoidea, 13–19 × 23–25 microns, habenta unam guttulam maximam et multas parvas; paraphyses filiformes, sursum clavatae.

In terro in silvis densis. In venta Maia, Easton, Washington, Amer. bor

10. **Paxina recurvum** sp. nov.

Apothecia with short thick stalks, widespreading, reaching a diameter of 10 or more cm., with a strongly recurved margin on three or more sides giving the top an angular appearance, externally dull-white, finely tomentose; stalk short and thick, 2–3 cm. long and up to 3 cm. wide where it joins the apothecium, whitish, slightly lacunose, tomentose; excipulum prosenchymatous, consisting of interwoven, swollen-celled hyphae; hymenium convex, smooth to wavy, light brown; asci cylindrical, with a narrow twisted base, 325–350 × 13–15 microns, 8-spored; spores broad-ellipsoid, 14–16 × 9–11 microns, with two large oil-drops, very minutely roughened by small warts; paraphyses up to 8 microns at the apex, brown, sparingly septate.

On ground in dense woods. Snoqualmie Pass, April 14, 1934; Lake Keechelus, May 5, 1934.

This species is unlike any of the other *Paxinas* because of its repand habit but possesses a stalk and a tomentose exterior.

Apothecia stipitata, expansa late, 10 cm. in latitudine, margine recurva in lateribus tribus aut pluribus, exterriter "dull-white," tomentosa; stipes 2–3 cm. in longitudine et ad 3 cm. in latitudine, albus, lacunosissimus, tomentosus; excipulum prosenchymatum, de hyphis intermixtis cellarum tumidarum; hymenium convexum, leve aut undulatum, "light-brown"; asci cylindracei, pede angusto torto, 325–350 × 13–15 microns, octospori; sporidia late ellipsoidea, 14–16 × 9–11 microns, duabus magnis guttulis, asperula; paraphyses filiformes, sursum clavatae.

In terra in silvis densis. In venta Avril, Snoqualmie Pass, Washington, Amer. bor.

11. PEZIZA BUFONIA Pers. ex Fries.

Apothecia sessile, shallow cup-shaped, with upturned, even or notched margin, reaching a diameter of 5 cm., externally brown, warted; excipulum consisting of large swollen cells interspersed between swollen-celled hyphae, outer cells pseudoparenchymatous, grouped to form wart-like pustules; hymenium concave to plane, brown; asci 350–400 × 20–24 microns, cylindrical, 8-spored; spores 1-seriate, ellipsoid, smooth, 10–12 × 18–20 microns; paraphyses slender, slightly enlarged above to 8 microns.

On rich soil and garbage dumps. Common near Seattle in March.

This is the first report for this species in the United States.

12. PITHYA VULGARIS Fuckel.

On recently killed branches of fir above snow-line. Snoqualmie Pass, March 11, 1934.

This uncommon species is characterized by its spongy texture, spherical spores and habitat.

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PERFECT STAGE OF THE SWEET ORANGE FRUIT SCAB FUNGUS [1]

A. A. Bitancourt and Anna E. Jenkins

(with 2 figures)

The causal fungus of sweet orange fruit scab was identified and described as *Sphaceloma Fawcetti viscosa* Jenkins in 1933 (**3**) on the basis of the fungus as found on Bahia Navel (*Citrus sinensis* Osb.) from Limeira and Sorocaba, leading citrus centers in São Paulo, Brazil. The subsequent search for the perfect stage of this fungus has been rewarded by its discovery, also on the Bahia

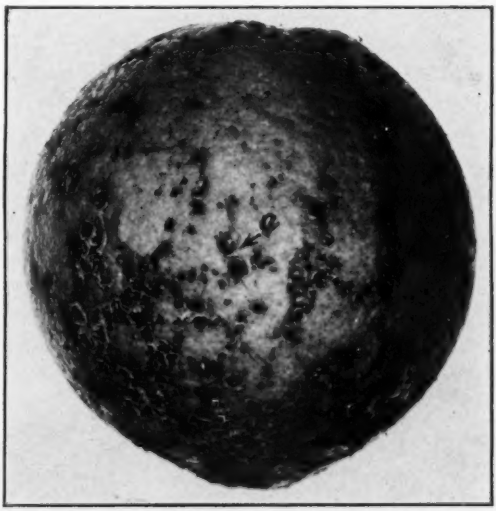

Fig. 1. Lesions of sweet orange fruit scab on sweet orange from the State of São Paulo. × 1.

Navel from São Paulo. This myriangiaceous ascomycete, an *Elsinoe*, was found on only one of a large number of severely

[1] Contribution from the Instituto Biologico de São Paulo, and the Bureau of Plant Industry, Washington, D. C.

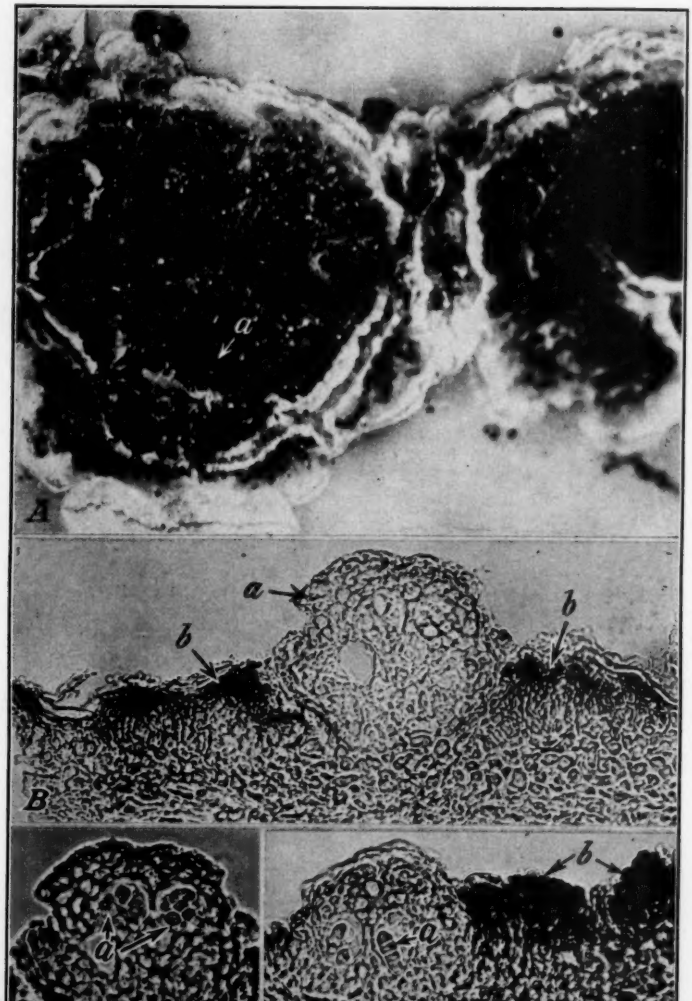

FIG. 2. *Elsinoe australis*. Lesions in figure 1, *a*, enlarged to show ascomata. × 20. B, an ascoma (*a*) protruding through conidial layer (*b*). C, *a*, clearer view of asci. D, another ascoma, showing 3-septate ascospore (*a*); *b*, conidial layer. B–D, × 600.

diseased fresh ripe Navels received on July 4, 1936 (FIG. 1). Ascomata were present on a limited number of lesions and were abundant only on those shown in figure 2, *a*.

On lesions, blackened by the conidial layer of the imperfect stage, the ascomata were recognized by the fact that some of the pustules as examined by the binocular were black on the periphery only, while the center was buff. These pale areas (FIG. 2, A, *a*) were ascomata, which had formed as an ectostroma within the conidial layer. The ascomata were in all stages of development, although immature for the most part. They were globose or nearly so, with well developed pseudoparenchyma, in contrast to the more scanty flattened ascomata of *Elsinoe Fawcetti* Bitancourt and Jenkins (*Sphaceloma Fawcetti* Jenkins) (**1**). The ascospores were also larger and more variable than those observed for *E. Fawcetti*.

It is believed that these differences, together with those of the conidial stages, already shown (**2**, **3**), warrant the separation of the variety *viscosa* from *E. Fawcetti* as a distinct species, as has been contemplated from the first. The distinguishing varietal name *viscosa* was chosen because of the extremely viscous nature of the cultural growth, although viscosity is now known to be only one of the numerous variations in cultures of this fungus (**3**). In treating the new *Elsinoe* as a species, the name *australis* is suggested for the perfect stage, as well as for the conidial stage when referred to as of the genus *Sphaceloma*, i.e., *S. australis*. The following diagnosis of the ascomycete is given:

Elsinoe australis sp. nov.

Ascomata globose, sometimes flattened or irregular, occasionally confluent, 40–120 μ in diam., buff, embedded in the tissues of the perfect stage, erumpent, consisting of a hyaline or slightly yellowish pseudoparenchyma devoid of a well defined epithecium; asci often distributed in the upper part of the ascoma, globose to obclavate, inner wall thickened apically, 15–27 $\times$ 13–21 μ; ascospores hyaline, variable, straight or more or less curved, 2–4 celled, often markedly constricted not only at median septum, but also at the other two, sometimes with a longitudinal septum in the upper middle cell, which is frequently slightly larger than the other cells, 12–20 $\times$ 4–8 μ. Conidial stage, *Sphaceloma australis* Bitancourt and Jenkins.

Ascomatibus saepe globosis, 40–100 μ in diam., pallide flavidis to ochraceis, in textura fructificationis conidicae immersis, dein erumpentibus; ascis 15–27 × 13–21 μ; ascosporis 2–4-cellulatis, 12–20 × 4–8 μ.

On *Citrus sinensis* Osb. var. Bahia Navel, causing lesions of the disease known as sweet orange fruit scab, São Paulo, probably Torrinha, received July 4, 1936. In Herb. Phytopath. Instituto Biologico de São Paulo, Brazil, No. *2256*.

Similar to *Elsinoe Fawcetti*, but with different host adaptations; separable from it in several morphological characters, including well developed globose ascomata, longer ascospores, apparent absence of a well developed epithecium, and persistent conidial stage not characterized by the *Cladosporium*like development of *E. Fawcetti*, which is more evanescent.

LITERATURE CITED

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2. **Bitancourt, A. A. & A. E. Jenkins.** Sweet orange fruit scab caused by *Elsinoe australis*. Jour. Agr. Res. In press.
3. **Jenkins, A. E.** A *Sphaceloma* attacking Navel orange from Brazil. Phytopathology **23**: 538–545. 1933.

NOTES AND BRIEF ARTICLES

Species of the higher fungi more and more are being distinguished on the basis of such details of microscopic structure as the make-up of the cuticle, etc. For example, *Pluteus coccineus* has been recognized as distinct from *P. leoninus* not only in color, but also in having a cuticle made up of globulose cells instead of interlaced hyphae. Similarly, the boletes of the group Versipelles (*scaber-versipellis* group) are slowly being disentangled partly on this basis. In this complex, it is important not only to make careful distinctions between those species which have a glabrous surface and those which are fibrillose or tomentose, but also it has become apparent that the fundamental nature of the glabrosity must be used, as for example in the white forms variously called *B. niveus*, *B. albellus* and *B. holopus*, etc. In these species (or varieties, as some of them have been called), surfaces that to the naked eye or a hand lens appear truly glabrous, smooth and shiny, will be found when examined microscopically to vary as above noted.

In this connection it seems to be important to have proper terms not only to describe the condition but also to emphasize the difference. Therefore, the following terms are proposed: GLOBULOSE-GLABROUS, referring to a cuticle which is glabrous and which microscopically consists of globular cells; FIBRILLOSE-GLABROUS, referring to a cuticle which is truly glabrous, perhaps shiny, and not at all fibrillose or subtomentose even under a hand lens, but which microscopically is seen to be composed of matted or interlaced hyphae.

Under the higher powers of a binocular dissecting microscope, or occasionally under a hand lens, the hyphal nature of a FIBRILLOSE-GLABROUS surface is usually readily detected, but the hyphae are more or less matted and often fused, at least in strands, often making a macroscopically shiny surface, while a

GLOBULOSE-GLABROUS surface on the other hand, is pebbly or cobbled when magnified. It is believed that greater clarity could be attained if the terms "tomentose" and "subtomentose" could be used only when the surface is distinctly and definitely woolly under a hand lens; "fibrillose" when the fibrils are quite distinct from the layer from which they arise and upon which they rest; and "glabrous" for all conditions of smoothness in which no details of surface structure are absolutely distinct under a hand lens, in which there are no hyphae or fibrils loose or separable from the pellicle proper, or in which hyphae are at all massed, matted or coalesced in such a way that the identity of individual hyphae or fibrils is not plain. Resort to the microscope will then clarify the fundamental nature of the glabrous condition.

It is suggested that these newly proposed terms be used only as referring to microscopic details and that "fibrillose-glabrous" be not used for a condition which may seem more or less glabrous with some fibrillar elements.—WALTER H. SNELL, BROWN UNIVERSITY, PROVIDENCE, R. I.

NOTICES

The headquarters of the Mycological Society of America at the Atlantic City meeting of the A.A.A.S., Dec. 28, 1936, to Jan. 2, 1937, will be at the Ambassador, Boardwalk at Brighton Ave. This hotel is also the headquarters of related botanical societies. The rates for rooms are $3.00 to $6.00 a day for a single room and $6.00 to $10.00 a day for a double room with twin beds. All rooms are with bath, and on the European Plan.

Institutions or individual members of the Society desiring space for their exhibits should write directly to F. C. Brown, Director of Exhibits, Smithsonian Institution Building, Washington, D. C. The A.A.A.S. pays the cost of booth rental for exhibits from Educational Institutions. Since a goodly proportion of the space is already taken, it is highly advisable that members who wish to exhibit for themselves or their institution apply as soon as possible.

The 100th meeting of the A.A.A.S. will be held at Denver in June 1937. This will be a joint meeting of the Pacific, Southwestern, and Eastern Divisions and thus will give an excellent opportunity to meet colleagues from all parts of the country in a location that is "a delightful one both for summer activities and also by virtue of the many attractions it offers for those interested in different fields of science and to lovers of nature. . . ." The Executive Committee of the A.A.A.S. plans to have special features and hopes to welcome distinguished visitors from abroad to add emphasis to the One Hundredth Meeting. It is hoped that all those that can possibly arrange to do so will plan to attend the meeting at Denver.

NOTE ON THE DISTRIBUTION OF FUNGI

The extreme minuteness of the spores of many species of fungi is doubtless an important factor in contributing to their ubiquity. The author of a work on botany has professed to the belief that a vigorous kick delivered to a large ripe puffball can raise spores that may be caught into air currents capable of carrying them around the globe.

Butler and Bisby in their Fungi of India devote eight pages to a comparison of the known fungi of that country with those of Europe and temperate America. Twenty-one per cent of the Manitoba rusts are already known to occur in India. In S. C. Teng's list of Chinese Discomycetes out of over 50 species described in his list only three had not been previously described as European or American. In 1931, the veteran Danish agaricologist, Jacob E. Lange, made a trip across the middle latitudes of this continent for the express purpose of comparing the fleshy fungi of the region traversed with those of Europe. The last statement in his interesting report of the trip in the first twelve pages of MYCOLOGIA, Volume XXVI, is that his strongest impression was of the evidence of the wonderful cosmopolitanism of the Agarics. He concludes with the question—Who can trace the aerial course of a spore?

Another Danish botanist who has worked on Arctic fungi for thirty-five years—Jens Lind—has summarized his researches on

their circumpolar distribution published in English in Meddelelser, Vol. XI, Part 2, 152 pages. He has not found a single genus peculiarly indigenous to the polar regions. Species that followed the retreating ice cap and those that climbed the mountains keeping near the snow line, although separated now for 15,000 years, have not evolved any noteworthy differences.—JOHN DEARNESS.